Scientific and Technical Personnel In Industry 1960

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The survey was conducted and the report was prepared in the U.S. Department of Labor's Bureau of Labor Statistics under the general direction of Cora E. Taylor. William L. Copeland had supervisory responsibility for the project. The data were analyzed and the report was prepared by Samuel Saben, with the assistance of Sylvia K. Lawrence and Larry M. Jolliffe. The clerical work was supervised by Beatrice E. Goins. Hyman B. Kaitz acted as statistical consultant; John W. Gracza devised the electronic computing methodology, with the assistance of Brendan J. Powers; and Edmund W. FitzGerald directed the machine tabulation operations.

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PREFACE

This report presents the major findings of a 1960 survey of employment of scientific and technical personnel in private industry. The survey was conducted for the National Science Foundation by the Bureau of Labor Statistics of the U.S. Department of Labor as a part of a comprehensive program of studies of scientific and technical personnel in all sectors of the economy. Related surveys cover Federal and State Government agencies, colleges and universities, and nonprofit research institutes and foundations.

The 1960 survey was carried out through questionnaires mailed to a sample of companies carefully selected to be representative of the Nation's industry. The response to the survey was excellent; usable information was received from about 90 percent of the approximately 10,500 companies in the sample.

The figures presented in the report, like all estimates derived from sample data, are approximations subject to sampling and other errors. Furthermore, certain small companies employing relatively few scientific and technical personnel were outside the scope of the survey. These matters, as well as other definitional and technical problems, are discussed in Appendix B—Scope and Method—and in Appendix C—Technical Notes.

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HIGHLIGHTS OF THE SURVEY

Employment of scientists and engineers in industry increased by approximately 6 percent between January 1959 and January 1960—a rate of growth greater than that for total industrial employment. The rise in scientific and engineering employment was greater in research and development than in other activities. The growth rate for scientists exceeded that for engineers.

The nearly 813,000 scientists and engineers within the scope of the 1960 survey represented about 95 percent of the estimated total number employed in industrial firms and in their own businesses. Engineers, numbering 648,900, accounted for 80 percent of all scientific and engineering personnel included in the survey; the 77,000 chemists accounted for nearly 10 percent; and the remainder consisted of 19,800 life scientists, 15,600 physicists, 15,300 earth scientists, 14,100 mathematicians, 12,700 metallurgists, and a residual group of 9,200 "other" scientists.

Employment of engineers was about 5 percent higher in January 1960 than in January 1959. Among the scientists, biological scientists and mathematicians had the greatest growth; metallurgists and chemists also had a greater growth rate than the average for all scientists and engineers.

Chief employers of scientists and engineers were the aircraft, electrical equipment, chemicals, and machinery industries. Approximately 45 percent of all scientific and engineering personnel were in these industries in 1960. Moreover, in aircraft and chemicals manufacturing, scientists and engineers accounted for 12 percent and 9.6 percent of total employment in the respective industries; this compares with 2.8 percent for all industries combined.

More than half (52.3 percent) of all scientific and engineering personnel were in companies with 5,000 or more employees in January 1960. In manufacturing industries alone, firms of this size employed 62 percent of the scientists and engineers but only 40 percent of all employees. Furthermore, these large firms employed nearly 70 percent of the scientists and engineers engaged in research and development in manufacturing.

The major function of 38 percent of industry's scientists and engineers in early 1960 was production and operations. The second largest group (32 percent) was engaged in the performance of research and development; in addition, nearly 6 percent were primarily concerned with administering R&D work. About 90 percent of the 302,500 scientists and engineers primarily engaged in R&D worked full time in this activity. Industries composed mainly of large companies with extensive R&D programs tended to have the highest proportions of scientists and engineers working full time in this type of work.

The 594,000 technicians in American industry in January 1960 represented an increase of approximately 8 percent over the comparable January 1959 figure. The ratio of technicians to scientists and engineers also increased over the period. Of every 10 technicians in 1960, about 5 were engineering and physical science aids, 3 were draftsmen, and the remainder were medical, agricultural, biological, or other technicians.

Technicians were utilized throughout industry, but about 44 percent were employed in four industry groups—electrical equipment, machinery, and aircraft manufacturing industries and the engineering and architectural services.

Nearly 161,000 technicians, or 27 percent of the number in all activities, were primarily engaged in research and development. R&D technicians were concentrated in large companies in those industries also using many scientists and engineers in R&D work. The ratio of R&D technicians to R&D scientists and engineers was 53 per 100 in early 1960.

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EMPLOYMENT OF SCIENTISTS AND ENGINEERS

Scientific and technical personnel are a critically important national resource both to the defense of the country and to general economic progress. As the major part of a program to gather basic information needed to quantify this resource and evaluate the trends that characterize its development, a nationwide survey of scientific and technical personnel in industry is undertaken annually.

The 1960 survey obtained data on the numbers of scientists, engineers, and technicians classified by broad occupational group, type of industry, size of employing company, and the major function performed for employers by these personnel. The data refer to all of private industry, with minor exceptions. Excluded were the relatively few self-employed scientists and engineers and scientific and technical personnel working for firms (most of them small) outside the scope of the survey.[1]

Number Employed in 1960

Approximately 813,000 persons were working as scientists or engineers in January 1960 in companies within the scope of the survey.[2] Since the exclusions probably amounted to between 4 and 5 percent of all scientists and engineers in private industry, the total was about 850,000. Members of the engineering profession accounted for about 8 out of 10 (649,000) of all scientific and engineering personnel included in the survey. Nearly 1 in 10 (77,000) was a chemist. Of the remainder (87,000), physicists, geologists and geophysicists, metallurgists, and mathematicians were the principal scientific groups—each numbering between 12,000 and 16,000. (See table 1.)

Employment Trends

The data obtained from this survey indicate an increase of 6.4 percent in the number of scientists and engineers between January 1959 and January 1960, compared with the 4.6-percent growth which occurred between January 1958 and January 1959 (table 1).[3] Employment in the dominant engineering group rose by 5.4 percent from 1959 to 1960, compared with a growth of 4.8 percent in the earlier period. Scientists, as a group, grew more rapidly than engineers between 1959 and 1960. However, employment in the various scientific occupational groups showed widely varying rates of growth in the recent period, and also considerable variation from the employment changes which occurred between 1958 and 1959. The employment of mathematicians and metallurgists continued to expand rapidly, increasing at rates much greater than the average for all scientists and engineers. The number of chemists rose by nearly 8 percent between January 1959 and January 1960, in contrast with their less-than-average growth during the earlier period (1958–59). On the other hand, physicists registered a

TABLE 1.—*Scientists and engineers, by occupational group, January 1959 and January 1960, and percent change*

Occupational group	Number		Percent change	
	January 1959[1]	January 1960	1958 to 1959[1]	1959 to 1960
All groups	764, 100	812, 700	4. 6	6. 4
Engineers	615, 400	648, 900	4. 8	5. 4
Chemists	71, 500	77, 000	2. 9	7. 7
Physicists	14, 900	15, 600	11. 4	4. 9
Metallurgists	11, 400	12, 700	7. 3	11. 4
Geologists and geophysicists	14, 800	15, 300	−4. 1	3. 6
Mathematicians	11, 300	14, 100	16. 9	25. 3
Life scientists	18, 200	19, 800	8. 6	9. 1
Medical scientists	7, 000	6, 600	4. 5	−6. 4
Agricultural scientists	5, 600	5, 900	11. 3	5. 7
Biological scientists	5, 500	7, 300	11. 4	32. 1
Other scientists	6, 600	9, 200	−14. 7	38. 9

NOTE.—Totals and percentages have been calculated on the basis of unrounded figures and therefore may not correspond exactly with the rounded figures shown.

[1] Source: National Science Foundation, *Scientific and Technical Personnel in American Industry—Report on a 1959 Survey*—NSF 60-62 (U.S. Government Printing Office, Washington, 1960).

[1] The number of companies employing scientists or engineers in January 1960 was estimated to be nearly 50,000—70 percent of which had fewer than 100 employees of all types. For a discussion of number of companies employing scientists and engineers, see National Science Foundation, *Scientific and Technical Personnel in American Industry—Report on a 1959 Survey*—NSF 60-62 (U.S. Government Printing Office, Washington, 1960), pages 5–7 and tables A–1 and A–2.

[2] See appendixes B and C.

[3] See also, National Science Foundation publication cited in footnote 1.

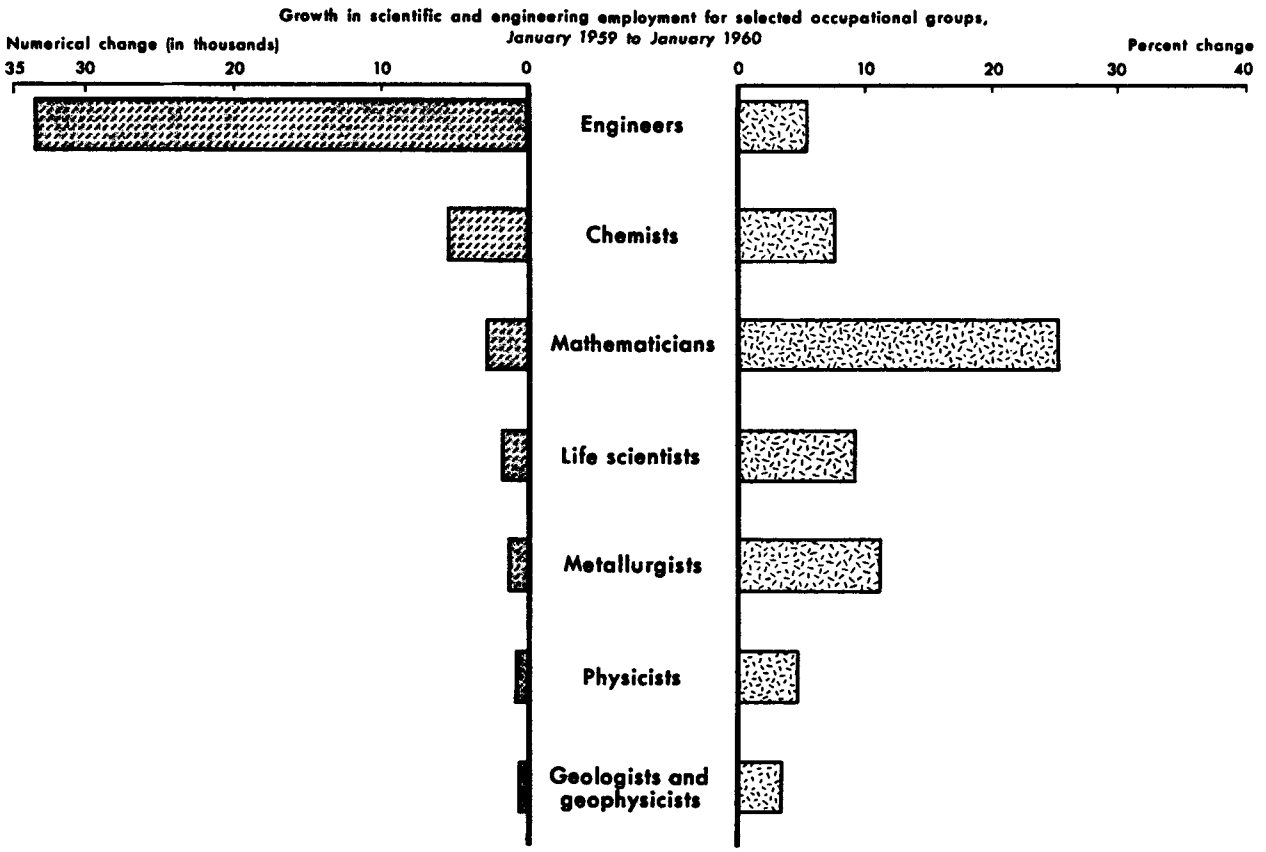
moderate gain (4.9 percent) between 1959 and 1960, after their markedly above-average increase (11.4 percent) of the previous year. Geologists and geophysicists—an occupational group with a downward employment trend between early 1958 and early 1959—showed a slight employment increase during the year ending in January 1960. (See chart 1.)

Variations in growth among the occupational groups are not readily explained by the limited data obtained from the surveys. Part of the cause is undoubtedly related to the rate of growth in industries which are important users of the various types of scientific personnel—or, more specifically, to the extent of R&D activity in companies within an industry. Other important aspects of occupational change are the shifts in position titles which result from company reorganizations, changes in emphasis on types of work programs, and other factors. For example, persons once classified as engineers or physicists, who have an extensive background in mathematics, may have been assigned the title of mathematician when their work shifted to projects more concerned with mathematical problems. Recent rapid growth in areas such as those concerned with applying mathematical techniques to research in the natural sciences and engineering and those related to electronic data processing is well known.[4] It may be that the number of mathematicians, as well as some other occupational groups, has grown partly as a result of shifts in personnel among occupations.

The percent changes shown for the smaller occupational groups should be interpreted with caution. Since the medical, agricultural, biological, and "other" scientist groups are each very

[4] For detailed information on persons in mathematical employment see National Science Foundation, *Employment in Professional Mathematical Work in Industry and Government—Report on a 1960 Survey* (U.S. Government Printing Office, Washington, 1961), in press.

Chart 1. Numerically, engineers had the greatest growth from 1959 to 1960; proportionately, mathematicians showed the greatest increase.....



small, minor absolute changes in their numbers occasion relatively large percentage changes. For example, the decline of 6.4 percent shown for medical scientists was the result of an estimated numerical change of only about 400. On the other hand, the increase of 5.4 percent for engineers was associated with a numerical change of 33,500. Changes based on the larger numbers are likely to have far greater significance than those related to very small numbers. (See appendix C, table C–5, for standard errors by occupation.) Furthermore, the "other scientists" group is a residual category of uncertain content. If respondents specified an occupational title for employees reported in this category, it was sometimes possible to allocate the personnel to one of the scientific occupational groups identified on the questionnaire. However, few respondents did specify occupational titles for personnel reported in this miscellaneous category. When they did, most of the reported personnel appeared to belong either to interdisciplinary fields or to new specializations, which respondents were reluctant to classify into the broad occupational groups used in the survey. It may be that newly emerging areas of specialization, which foster new job titles (e.g., electronic scientist), account for a part of the unusual growth in the "other scientists" category.

Number by Major Industries

One of the more stable features of the employment of scientists and engineers is the pattern of distribution of these personnel among major industries. There has been little change in recent years in either the proportion of scientists and engineers employed in the various industries or in the ratio of such personnel to total employment in any given industry.[5] The concentration of scientists and engineers in specific industries is shown in table 2 for 1959 and 1960, and in greater occupational detail for 1960 in appendix table A–1.

About 45 percent of all scientific and engineering personnel were employed, in early 1960, in the following industries: Aircraft, electrical equipment, chemicals, and machinery. Large concentrations of scientists and engineers in these industries are to be expected, since their activities are predominantly science based, involving complex and dynamic technologies. Within the many big companies classified in these industries are to be found the country's largest research and development operations. It was not surprising, therefore, to find that these four industries accounted for nearly two-thirds (64 percent) of all scientists and engineers employed in R&D activities in 1960.

Engineers, although concentrated in the aircraft, electrical equipment, and machinery industries, were important numerically in every industry. In only two industries for which separate estimates were made—food and kindred products and chemicals and allied products—did engineers constitute fewer than half of all workers classified as scientists and engineers.

Several of the scientific occupational groups are concentrated very heavily in one or two industries. Three-fifths of the life scientists and more than two-fifths of the chemists were employed in the chemicals industry. The electrical equipment and aircraft industries together employed three-fifths of the physicists and two-fifths of the mathematicians. More than two-fifths of the metallurgists were in the primary metal industry, and three-fourths of the geologists and geophysicists were in the petroleum products and extraction industry.

Despite the heavy concentrations of certain occupational groups by individual industry, most industries (shown in appendix table A–1) employed at least a few members of each occupational group. The employment of specialists in a variety of fields is related to the growing technological complexity of many industrial products and also to the increasing diversification of company interests. Companies in this survey were classified in the industry of their principal activity; therefore some of the scientists and engineers shown in any given industry undoubtedly were employed in work related to another industry classification.[6] Furthermore, some companies

[5] National Science Foundation, *Scientific and Technical Personnel in American Industry—Report on a 1959 Survey* (1960); *Science and Engineering in American Industry—Report on a 1956 Survey* (1959); and *Science and Engineering in American Industry—Final Report on a 1953 Survey* (1956). U.S. Government Printing Office, Washington.

[6] Most companies active in several industries are large employers of scientists and engineers, but the industry classification of each company was necessarily determined by the company's principal product. For example, a company may produce such diverse products as electrical equipment, machinery, aircraft, scientific instruments, and chemicals. The industry classification of scientists and engineers would be much more precise if the reporting units of the survey were establishments of participating companies, since establishments are less likely to cross industry classification lines.

carry on basic research not related to any one product.

Of the 17 industry groups for which employment estimates are presented in appendix table A–2, all but 1 (food and kindred products) showed increases in the employment of scientists and engineers between January 1959 and January 1960. The rates of increase differed markedly between manufacturing and nonmanufacturing industries. The overall growth of 6.4 percent for all industries was surpassed by the 7.3-percent increase in the use of scientists and engineers in manufacturing; this contrasted with the 3.5-percent increase in nonmanufacturing industries. In the latter category (which accounted for 25 percent of all scientists and engineers in January 1960), no specific industry group showed a percentage increase as high as 4 percent. On the other hand, 9 of the 13 manufacturing groups increased their use of scientists and engineers by 7 percent or more between January 1959 and January 1960. The low rates of growth in the employment of scientists and engineers in the construction industry (3.2 percent) and the related engineering and architectural services industry (1.3 percent) were a reflection of the general economic climate in the construction industry during 1959. Much of the increase shown for the transportation and other public utilities group (3.8 percent) was attributable to the 4-percent increase in the public utilities and sanitary services component, which accounted for 70 percent of the scientists and engineers for this industry group.[7] (See appendix table A–2.)

The ratio of scientists and engineers to total employment in each industry group shows year-to-year stability. Nevertheless, the expansion in scientific and technical employment was more rapid than that in total employment. For all industries taken together, 28 of each 1,000 employees were scientists or engineers in January 1960, compared with 27 per 1,000 in January 1959 (table 2). Between the two dates, 3 of the 16 industry groups showed no change; of the remaining industries, 10 showed an increase in the proportion of scientists and engineers to total employment, and only 3 showed a decrease in this ratio. In all cases the changes were slight, with only the aircraft industry showing an increase as great as 1 percentage point.

TABLE 2.—*Scientists and engineers as percent of total employment, by industry, January 1959 and January 1960*

Industry	January 1959 [1]	January 1960
All industries	2.7	2.8
Food and kindred products	0.7	0.7
Textile mill products and apparel	.3	.4
Paper and allied products	1.7	1.6
Chemicals and allied products	9.0	9.6
Petroleum products and extraction	7.2	7.7
Stone, clay, and glass products	1.8	2.0
Primary metal industries	2.6	2.5
Fabricated metal products and ordnance	3.0	3.3
Machinery (except electrical)	4.2	4.2
Electrical equipment	7.6	7.7
Aircraft and parts	10.7	12.0
Professional and scientific instruments	6.9	7.4
Other manufacturing industries	1.4	1.5
Construction	3.4	3.1
Transportation and other public utilities	1.3	1.3
Other nonmanufacturing industries	1.4	1.5

NOTE.—January 1960 employment estimates used in this table were derived from the survey and hence apply to the same industry categories as the estimates of scientists and engineers. See appendix B for a discussion of the coverage of the survey.

[1] Source: National Science Foundation, *Scientific and Technical Personnel in American Industry—Report on a 1959 Survey*—NSF 60-62 (U.S. Government Printing Office, Washington 1960).

Among individual industries, aircraft is outstanding in its use of scientific and technical personnel; 12 percent of its employees were scientists or engineers in January 1960. The chemicals industry showed the next highest proportion of such personnel (9.6 percent), followed by the electrical equipment and petroleum products and extraction industries (each 7.7 percent) and professional and scientific instruments (7.4 percent). In all other industries for which separate estimates were made, the ratio of scientists and engineers to total employment was 4.2 percent or less.

When the industries shown in table 2 are analyzed in terms of the kinds of customers they serve, the broad outlines of a pattern of utilization of scientists and engineers emerge. The industries in which scientists and engineers comprised 7 percent or more of the work force are characterized by products requiring relatively large

[7] Specific percent changes in the total number of scientists and engineers employed in particular industries should not be interpreted as precise measures of the changes which may have occurred. Companies of comparable size in a given industry show very wide variations in the numbers of scientists and engineers reported in the survey. Because of such variations, the sampling errors of the estimates of percent change for a number of the industries shown in appendix table A–2 were large in relation to the corresponding percent change estimates; in general, the greater the range of a variable, the greater the sampling error of a change in the variable. See appendix table C–8 for the sampling errors.

inputs of R&D activity.[8] The aircraft and the electrical equipment industries serve primarily capital and military equipment markets. In the petroleum products and extraction industry, the ratio of scientists and engineers to the total work force is influenced also by the highly automated technology used in petroleum refining, which requires relatively few employees. Next in descending order were machinery, construction, fabricated metal products, and primary metals—each with less than 5 percent but more than 2 percent of the work force classified as scientists and engineers. These industries serve a mixed group of customers with consumer products and with industrial or capital equipment.

The industries in which scientists and engineers comprised only 2 percent or less of the work force were either trade or service industries or were among those concerned with the manufacture of consumer products or closely related operations (packaging, for example), which require a relatively small input of research and development.

Number by Size of Company

Large firms predominate in the employment of scientists and engineers, particularly in the manufacturing industries (table 3 and chart 2). Of all scientific and engineering personnel in industry, slightly more than half (52 percent) were in companies with 5,000 or more employees in January 1960. In manufacturing industries alone, firms with 5,000 or more workers accounted for the employment of 62 percent of the scientists and engineers but only 40 percent of all employees. Furthermore, these large firms employed 69 percent of the scientists and engineers engaged in research and development in manufacturing. It is evident that the concentration of scientists and engineers in large manufacturing firms is related to the extensive R&D programs of these organizations.

TABLE 3.—*Percent distribution of scientists and engineers, by size of company, in manufacturing and nonmanufacturing industries, January 1960*

Size of company	All industries	Manufacturing industries	Nonmanufacturing industries
All sizes	100.0	100.0	100.0
Under 500 employees	27.3	18.3	53.7
500–4,999 employees	20.5	19.5	23.2
5,000 or more employees	52.2	62.2	23.1

[8] See page 9 for discussion of scientists and engineers in research and development.

Nevertheless, substantial numbers of scientists and engineers are employed by small companies. About 27 percent of the scientists and engineers in industry in January 1960 were employed by firms with fewer than 500 employees. However, half of the scientists and engineers in these small firms were in nonmanufacturing industries—two-fifths in the engineering and architectural services industry and the construction industry—where the small company is the predominant form of organization.

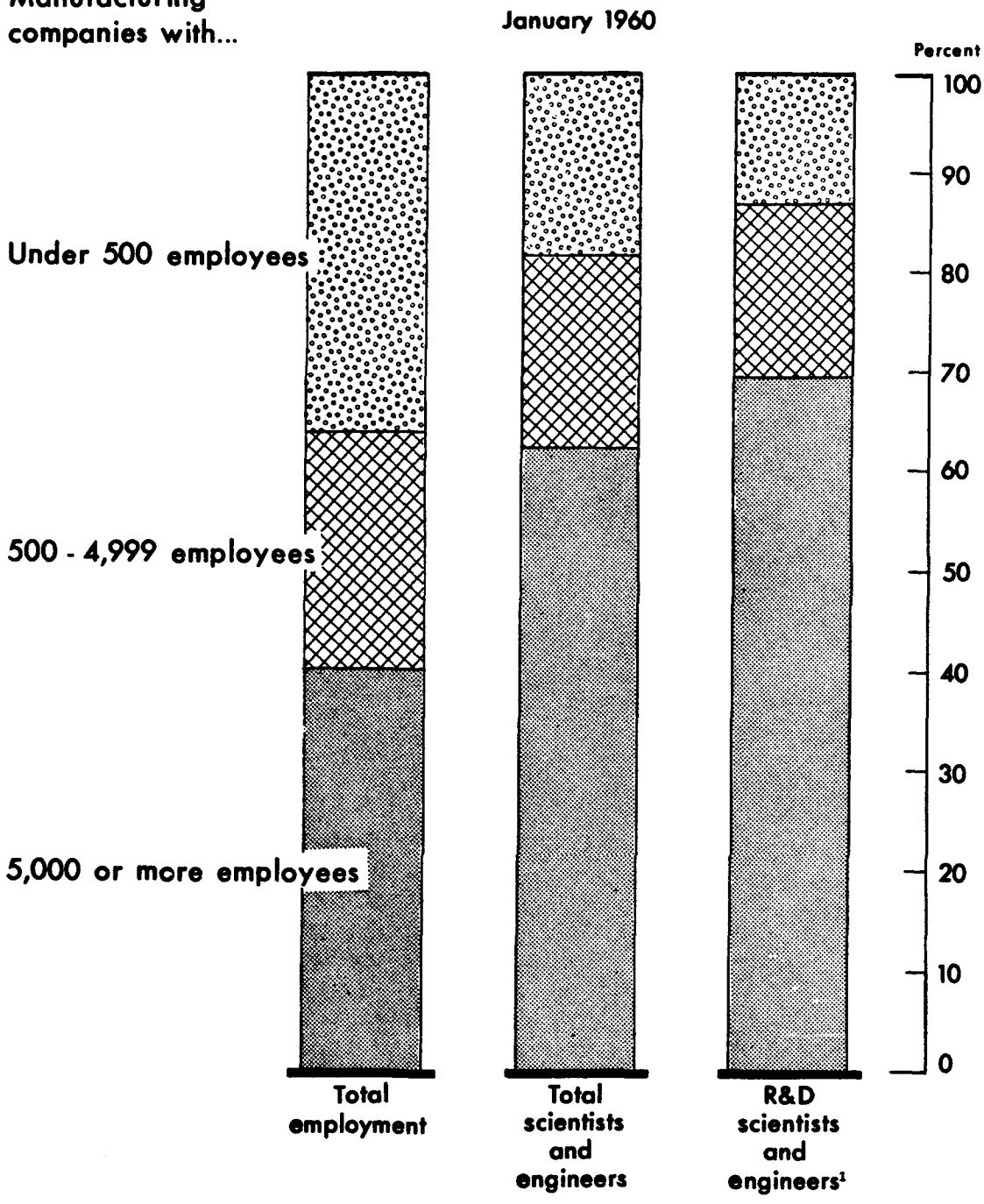
When the numbers of scientists and engineers are related to total employment there is further evidence that these professional workers are concentrated in large firms. In 1960, approximately 4 percent of all employees in the giant companies (5,000 or more employees) were scientists and engineers, compared with 2.5 percent in companies with 1,000 to 4,999 employees, and 2.2 percent or less in each of the smaller company-size groups (appendix table A–3).

The concentration of scientists and engineers in the largest companies is particularly high in the three industries which utilize the greatest numbers of scientists and engineers. In the aircraft and parts, electrical equipment, and chemicals and allied products industries, 92, 64, and 61 percent, respectively, of their scientific and engineering personnel were in firms with 5,000 or more employees in January 1960 (appendix table A–4).

In engineering and in each scientific occupation group, a much higher proportion worked for the largest companies than for smaller ones. Two-fifths or more of each of the scientific occupational groups were employed in companies with 5,000 or more workers; the percentages ranged from 40 percent for biological scientists to 84 percent for physicists. Employees in occupations important in R&D work tend particularly to be concentrated in larger firms. Only engineers, geologists and geophysicists, and agricultural scientists were employed in companies with fewer than 500 employees in proportions greater than the average (27 percent) for all scientists and engineers in companies of this size class. (See appendix table A–5.)

Between January 1959 and January 1960, companies with fewer than 500 employees showed proportionate as well as numerical increases in

Chart 2. Large companies have higher proportion of scientists and engineers than of total employees...



[1]Includes both scientists and engineers conducting and those administering R&D activities.

the employment of chemists, metallurgists, geologists and geophysicists, mathematicians, and biological scientists. These increases suggest a trend toward greater utilization of scientific personnel in small companies.

Primary Functions Performed

What kinds of work do scientists and engineers perform in industry? How many are engaged in research? What proportion are primarily concerned with administrative duties? How many do some R&D work in addition to their primary assignment? Detailed answers to these questions would impose a heavy reporting burden on the companies cooperating in the survey. Yet such information is of great importance to any assessment of the country's personnel resources in science and engineering.

To provide some data on the major activities of these professional workers, survey respondents were asked to classify scientists and engineers in six broad functional categories: Performance of research and development, management and administration of research-development, management and administration of other activities, exploration, production and operations, and all other activities. Since many employees perform more than one of these functions, respondents were asked to classify scientists and engineers in the one category in which they were primarily engaged (defined as the function occupying the greatest proportion of their time). In addition, respondents were asked to report the numbers employed full time and also the full-time equivalent of those working part time in research and development.[9]

Number in Research and Development and Other Activities. Nearly one-third of all engineering and scientific personnel were performing R&D work in January 1960; in addition, about 6 percent were primarily concerned with managing and administering R&D activities. However, the single leading activity of the scientists and engineers in industry was production and operations. The 310,000 personnel who were primarily engaged in production and operations constituted 38 percent of all scientists and engineers employed in industrial firms in 1960. (See appendix table A–6.) Management and administration of all activities other than research and development was the concern of 8 percent of the scientists and engineers. Most of the remainder were classified in "all other activities," which included functions such as operations research, technical sales and service, and purchasing.

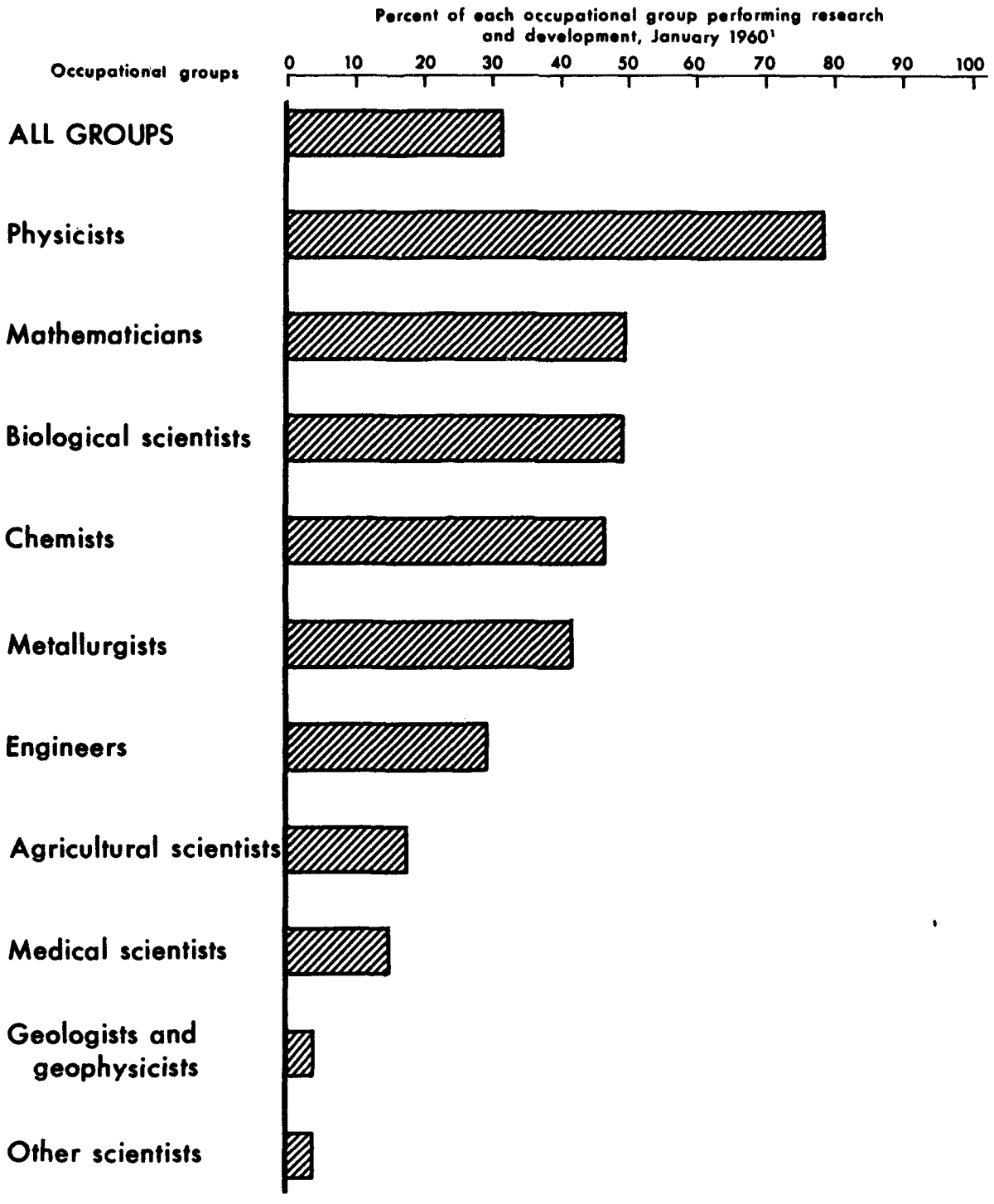
A trend toward greater concentration of scientists and engineers in R&D activities was evident. Between January 1959 and January 1960, scientific and engineering personnel performing and administering R&D work increased by approximately 9 percent, compared with a rise of only 5 percent for those engaged in all other types of activities.

In five of the nine scientific fields—physics, biological science, mathematics, chemistry, and metallurgy—more persons were primarily engaged in the performance of research and development than in any other single function; more than 40 percent of the personnel in each of these occupational fields were performing R&D work in January 1960 (chart 3). A great preponderance of physicists (79 percent) were engaged in the performance of R&D, and another 10 percent were administering R&D programs. More engineers were primarily concerned with production and operations (41 percent) than with any other function; geologists and geophysicists were concentrated in exploration (75 percent); and medical scientists had a high proportion (64 percent) in "all other" activities (many were pharmacists working as "detail men" for pharmaceutical organizations).

The distribution of scientists and engineers by function varies substantially by industry, as shown in appendix table A–7. Aircraft and parts and electrical equipment were the only industries which in early 1960 used more than 50 percent of their scientific and engineering personnel in the performance of research and development. On the other hand, six industries—textiles, paper, primary metals, construction, transportation and other public utilities, and engineering and architectural services—employed more than half of their engineers and scientists in work concerned with production and operations. Petroleum products and extraction was the only industry with a significant proportion of scientific and engineering personnel in exploration. Industries in which research and development was of limited significance (e.g., construction, transportation and other public utilities, engineering and architectural services, and primary metal industries) tended to have a high proportion of personnel engaged in the management and administration of "other activities."

[9] See reproduction of the questionnaire in appendix D for definitions of functions used in the survey.

Chart 3. More than three-fourths of physicists in industry are engaged in R&D work...



[1] Excludes persons administering R&D activities.

The relative rank of each industry, based on the proportion of both scientists and engineers performing and those administering research and development in January 1960, is shown in chart 4. Little change occurred over the previous year in the rank of industries or in the proportion of scientists and engineers assigned to the R&D function within each industry.[10]

The functional distribution of scientists and engineers appears to bear a relationship to size of company, as measured by total employment. The proportion of engineers and scientists in R&D work tended to increase with the size of company—from 13 percent for companies with fewer than 100 employees to 42 percent for firms with 5,000 or more employees (appendix table A–8). In production and operations, on the other hand, the percentage of scientists employed decreased with size—from 54 percent in companies with fewer than 100 employees to 33 percent in firms with 5,000 or more employees.

When all R&D functions were combined—performance and management and administration—they accounted for the activity of 37 percent of the scientists and engineers in industry, but there were widespread differentials by occupation within the various industry groups. For example, in only 3 of 17 industrial groups (aircraft, electrical equipment, and professional and scientific instruments) were more than 50 percent of the engineers engaged in R&D work. On the other hand, 10 industry groups used more than 50 percent of their chemists in research and development, and most industries utilized the majority of their physicists in R&D work. (See appendix table A–9.)

Additional data on the utilization of scientists and engineers may be found in appendix tables A–6 through A–8, which show functional distribution by occupation, industry, and size of company; tables A–9 through A–12 present the occupational, industrial, and size-of-company distributions of scientists and engineers engaged in research and development; table A–13 indicates the functional-industrial distribution of engineers alone.

Full-Time Equivalent Employment in Research and Development. The data on the number of scientists and engineers primarily engaged in the performance or administration of R&D work provide a measure of these resources which avoids counting, more than once, those individuals who also perform some other function on a part-time basis. This is the most readily reported and most easily understood measure of employment by function. However, it is an incomplete measure of industry's commitment of scientific and engineering manpower resources to the R&D effort. To evaluate more fully the use of these critically important resources, companies were requested to report the number of scientists and engineers employed full time in the performance or administration of research and development and also the number employed only part time in such work converted to a full-time basis.[11] The sum of these numbers yields the full-time equivalent employment in R&D activities. The figures thus derived represent the total input of scientific and engineering personnel resources to R&D work. However, the response rate for the full-time equivalent question was lower, and the estimates may therefore be less reliable, than the data on scientists and engineers primarily engaged in research and development.

Approximately 272,700 scientists and engineers were estimated to have been employed full time in R&D work in January 1960. This estimate indicates that about 90 percent of the scientists and engineers primarily engaged in research and development (302,500) were working full time in this activity. The full-time equivalent number of scientists and engineers who were employed part time in research and development was 13,500.[12] When this number is added to the number working full time, the total is 286,200, or 94.6 percent of the number primarily engaged in R&D work (appendix table A–14).

The difference between the numbers representing full-time equivalent scientists and engineers and those primarily engaged in R&D work should be regarded as a minimum figure. Survey respondents were asked to report the same count for both items if the numbers were within 5 percent of each other.[13] The effect of this instruction was to increase the estimate of scientists and

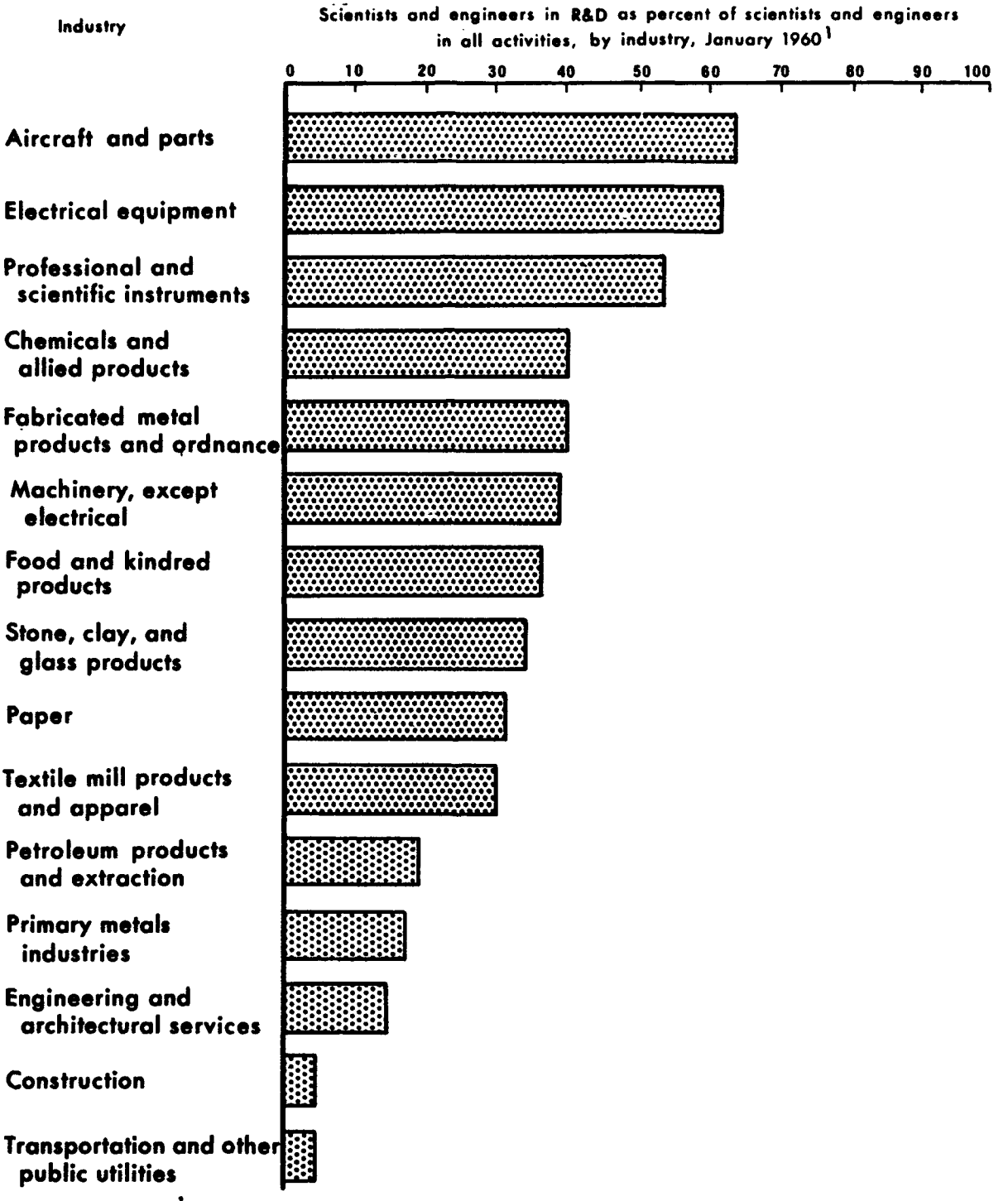
[10] The fabricated metal products and ordnance industry dropped from third to fifth place, from 1959 to 1960, as a user of scientists and engineers in research and development. However, this change is not necessarily significant because of the relatively high error rate for this industry (see appendix C).

[11] For example, two employees, each normally working in research-development for half the normal workweek, would equal one "full-time equivalent" employee.

[12] The total number of scientists and engineers represented by this figure, and the proportion of their time devoted to R&D activities, is unknown.

[13] See item 6 of the questionnaire in appendix D.

Chart 4. R&D is the principal activity of more than half the scientists and engineers in the aircraft, electrical equipment, and professional and scientific instruments industries.....



[1] Includes both scientists and engineers conducting and those administering R&D activities.

engineers in full-time employment and thus minimize the difference between the figures relating to "full-time equivalent" and "primarily engaged" employment. Nevertheless, it is evident that a substantial number of scientists and engineers contribute to the R&D program of their companies on a part-time basis, although their primary employment is in production or some other activity.

In the three industries employing the highest proportions of scientists and engineers in R&D work in January 1960—aircraft, electrical equipment, and chemicals—the differences between the "full-time equivalent" and the "primarily engaged" estimates were negligible. On the other hand, industries with low proportions of scientific and engineering personnel in R&D work (e.g., transportation and other public utilities, textile mill products and apparel, and engineering and architectural services) showed wide differences in these estimates. (See appendix table A–14.) Apparently industries made up largely of companies with substantial R&D programs, which are likely to be carried on in separately organized laboratories or other units, tend to have the lowest proportions of scientists and engineers working only part time in the R&D function.

EMPLOYMENT OF TECHNICIANS

Technicians employed in direct and indirect support of industry's scientists and engineers form an integral part of the Nation's resources of scientific and technical personnel and thus come within the scope of this survey. Although there is no general agreement on the occupations properly classifiable within the technician group, for purposes of this survey technicians were defined broadly to include:

> All persons engaged in work requiring knowledge of physical, life, engineering, and mathematical sciences comparable to knowledge acquired through technical institute, junior college, or other formal post-high school training, or through equivalent on-the-job training or experience.[1]

Implicit in the definition is the type of work performed by technicians. This work, although extremely varied, usually consists of either assisting the scientist or engineer directly or performing some of the tasks that otherwise would be done by him. In either case, engineering or scientific personnel are freed for duties requiring a higher level of training or experience. On the other hand, some companies employ technicians but not scientists or engineers; for example, architectural firms may employ draftsmen but no engineers.

Data were obtained in this survey on the total number of technicians employed as of January 1960 and on how many were draftsmen; engineering and physical science technicians; medical, agricultural, and biological technicians; and "other technicians."[2] In addition, information was sought on how many of the technicians were engaged primarily in research and development.

Overall Employment Estimates

Approximately 593,600 technicians were employed, in January 1960, by companies within the scope of this survey. This number represents an increase of approximately 8 percent over the comparable figure for January 1959 (table 4). The rate of increase in employment of technicians was greater than that for engineers and scientists.

Of every 10 technicians in industry in early 1960 about 5 were engineering and physical science aids, 3 were draftsmen, and the remainder were medical, agricultural, or biological technicians or were in the miscellaneous group of "other technicians".

TABLE 4.—*Technicians, by occupational group, January 1959 and January 1960, and percent change*

Occupational group	Number		Percent change
	January 1959 [1]	January 1960	
All groups	549,400	593,600	8.1
Draftsmen	195,200	210,000	7.6
Engineering and physical science technicians	250,300	284,600	13.7
Medical, agricultural, and biological technicians	16,100	16,100	.2
Other technicians	87,809	82,900	−5.9

[1] National Science Foundation, *Scientific and Technical Personnel in American Industry—Report on a 1959 Survey*—NSF 60-62 (U.S. Government Printing Office, Washington, 1960).

NOTE.—Totals and percentages have been calculated on the basis of unrounded figures and therefore may not correspond exactly with the rounded figures shown.

The greatest expansion in the technician group from January 1959 to January 1960 occurred among engineering and physical science technicians. The rise in employment of this occupational group was about 14 percent—nearly double the rate of growth for draftsmen, the next largest occupational group (table 4). Since these two groups accounted for more than 80 percent of all technicians covered by the report, the increase in their employment largely determined the overall trend. Of the other two occupational groups, medical, agricultural, and biological technicians

[1] See the questionnaire in appendix D for the full definition used.

[2] Because of the variety of job titles used in industry and the lack of standardized meaning of the term "technician," the categories of personnel included in the figures reported for each occupational group, as well as for the total, probably varied among respondents.

showed virtually no change, and the residual group—"other technicians"—decreased by nearly 6 percent.

Number in Major Industries

Although all major industries utilized technicians in January 1960, more than two-fifths of all technicians were employed in the electrical equipment, machinery, engineering and architectural services, and aircraft industries (appendix table A–15). There were some noteworthy differences in the distributions of the various technician groups by industry. For example, engineering and physical science technicians were concentrated in electrical equipment, telecommunications and broadcasting,[3] machinery, and aircraft; and draftsmen were employed chiefly in engineering and architectural services, machinery, and electrical equipment. Medical, agricultural, and biological technicians were employed primarily in medical laboratories[3] and, secondarily, in the chemicals and allied products industry. The patterns of employment by industry for the various technician occupational groups showed little change between 1959 and 1960.

Nearly all industries shared in the growth of technicians between January 1959 and January 1960. Only the aircraft industry showed a significant decrease (11 percent) in employment of these workers. This decline may be related to the overall drop in the industry's employment and also to the continuing shift from aircraft to missile production. Among other industries using large numbers of technicians, greater-than-average increases in technician employment occurred in electrical equipment, chemicals and allied products, fabricated metal products and ordnance, and machinery. Although the proportionate increases in technician employment were great in the food and textile industries, these changes are not considered significant among such small-scale users of technicians. Another industry—construction—also showed a high rate of growth in technician employment. However, since this industry is characterized by wide fluctuations in employment and is particularly affected by seasonal factors, comparisons based on employment data collected in January may not accurately reflect year-to-year changes. (See appendix table A–16.)

Although industry as a whole used 73 technicians for each 100 scientists and engineers in 1960 (table 5), half of the industries for which separate estimates are shown—engineering and

TABLE 5.—*Scientists and engineers, technicians, and ratio of technicians to scientists and engineers, by industry, January 1960*

Industry	All scientists and engineers	All technicians	Average number of technicians per 100 scientists and engineers
All industries	812, 700	593, 600	73
Food and kindred products	9, 900	8, 100	81
Textile mill products and apparel	5, 800	4, 700	82
Paper and allied products	10, 500	6, 500	62
Chemicals and allied products	90, 700	39, 500	44
Petroleum products and extraction	48, 600	18, 100	37
Stone, clay, and glass products	10, 200	5, 000	49
Primary metal industries	35, 100	17, 900	51
Fabricated metal products and ordnance	38, 100	37, 800	99
Machinery (except electrical)	71, 400	72, 100	101
Electrical equipment	101, 400	79, 200	78
Motor vehicles and equipment	35, 400	24, 500	69
Aircraft and parts	101, 500	46, 800	46
Professional and scientific instruments	26, 300	21, 300	81
Other manufacturing industries	22, 700	28, 000	123
Construction	45, 100	26, 800	59
Transportation and other public utilities	36, 700	27, 000	74
Engineering and architectural services	56, 900	63, 500	112
Other nonmanufacturing industries	66, 500	66, 800	100

NOTE.—Totals and percentages have been calculated on the basis of unrounded figures and therefore may not correspond exactly with those indicated by the rounded figures shown.

[3] Classified with "other nonmanufacturing industries."

architectural services, machinery, fabricated metals, textiles and apparel, professional and scientific instruments, food, electrical equipment, and transportation and other public utilities—had higher ratios. These ratios ranged from 74 technicians per 100 scientists and engineers for the transportation and other public utilities industry to 112 per 100 for engineering and architectural services. The high ratio found for engineering and architectural services was due, in part, to the employment by some architectural service firms of draftsmen who were supervised by architects instead of scientists or engineers. (Architects were not within the scope of the survey.)

Two industries—motor vehicles and aircraft—showed substantial decreases in the ratio of technicians to scientists and engineers from 1959 to 1960; both reported declines (much greater in aircraft than in motor vehicles) in the number of technicians employed, accompanied by a rise in the employment of scientists and engineers. The other industries which showed significant changes in the ratio of technicians to scientists and engineers (food, textiles and apparel, and construction) reported sharp numerical increases in the employment of technicians.

Number by Size of Company

Technicians, like scientists and engineers, work in companies of all sizes throughout industry. However, technicians tend to be less concentrated in very large companies, as shown in the following distribution of employment in January 1960:

Size of company	*Technicians*	*Scientists and engineers*
All sizes of companies	100.0	100.0
Under 500 employees	38.1	27.3
500 to 4,999 employees	17.9	20.4
5,000 or more employees	44.0	52.3

The same industries—those with a complex and advanced technology—that employ many scientists and engineers in their very large companies also have a heavy concentration of technicians in these firms. In aircraft, motor vehicles, primary metals, chemicals, and electrical equipment, about 60 to 90 percent of the technicians worked in companies with 5,000 or more employees (appendix table A–17). In some other industries, however, where the small firm plays a more important role, considerable numbers of technicians were used in enterprises with relatively few employees. For example, more than three-quarters of the technicians in engineering and architectural services [4] worked in companies with fewer than 100 employees; corresponding proportions of technicians for firms of the same size in the fabricated metals and construction industries were 38 and 34 percent respectively.

The distribution of technicians by occupation among companies of different sizes indicates that more than half (55 percent) of all engineering and physical science technicians were working in companies with 5,000 or more employees. On the other hand, nearly half (48 percent) of the medical, agricultural, and biological technicians worked in companies with a total employment of under 100 (chiefly small medical laboratories); and draftsmen tended to be concentrated in the largest and the smallest firms. (See appendix table A–18.)

Number in Research and Development

About 160,600, or 27 percent of all technicians, were engaged primarily in R&D activities in January 1960 (appendix table A–19), compared to 37 percent of the scientists and engineers primarily concerned with R&D work.

Those industries with the heaviest concentrations of scientists and engineers in R&D work also used large numbers of technicians in this area. Of every 100 technicians doing R&D work, 90 were in manufacturing industries—much the same proportion as for R&D scientists and engineers (91 percent). Aircraft, paper, chemicals, electrical equipment, and professional and scientific instruments had the highest proportions of technicians primarily engaged in R&D work; these industries (excepting paper) also were among those using a high proportion of scientific and engineering personnel in research and development.

[4] Classified with "other nonmanufacturing industries."

Table 6 indicates an overall ratio of 53 R&D technicians for every 100 scientists or engineers engaged in R&D work in early 1960. The ratios ranged from 34 technicians per 100 scientists and engineers in transportation and other public utilities to 92 per 100 in paper and allied products. In no industry did technicians outnumber scientific and engineering personnel in R&D work.

Although these proportions are illustrative of relationships between numbers of technicians and numbers of scientists and engineers in research and development, they do not reflect the magnitude of R&D technicians in different industries. For example, the electrical equipment, aircraft, and chemicals industries were the three largest employers of R&D technicians and together accounted for almost half of all technicians doing R&D work; nevertheless, each of these industries had a lower ratio of R&D technicians to R&D scientists and engineers than that (53 per 100) for all industries.

The proportion of technicians engaged in research and development tended to increase in relation to the size of the company. Of the 160,600 R&D technicians, approximately two-thirds worked in companies with 5,000 or more employees. Also, it appears that the larger the company, the greater was the proportion of R&D technicians to all technicians. As shown in appendix table A–20, this proportion generally increased with size of company from 7 percent for firms with under 100 employees to 41 percent for those with 5,000 or more employees. The overall ratio of 27 percent was exceeded only by the largest size firms—those with 5,000 or more employees.

TABLE 6.—*Scientists and engineers and technicians primarily engaged in research and development, and ratio of R&D technicians to R&D scientists and engineers, by industry, January 1960*

Industry	Number primarily engaged in research and development		
	Scientists and engineers [1]	Technicians	R&D technicians per 100 R&D scientists and engineers
All industries	302, 500	160, 600	53
Food and kindred products	3, 600	1, 900	51
Textile mill products and apparel	1, 700	1, 300	72
Paper and allied products	3, 300	3, 000	92
Chemicals and allied products	36, 600	17, 800	49
Petroleum products and extraction	9, 300	6, 000	64
Stone, clay, and glass products	3, 500	1, 700	50
Primary metal industries	6, 000	3, 700	61
Fabricated metal products and ordnance	15, 400	8, 400	54
Machinery (except electrical)	28, 200	14, 400	51
Electrical equipment	62, 600	32, 700	52
Aircraft and parts	64, 600	29, 000	45
Professional and scientific instruments	14, 100	8, 000	57
Other manufacturing industries	26, 100	17, 600	68
Construction	2, 000	1, 100	54
Transportation and other public utilities	1, 600	600	34
Engineering and architectural services	8, 300	4, 900	59
Other nonmanufacturing industries	15, 400	8, 700	56

[1] Includes scientists and engineers conducting and those administering research and development.

NOTE.—Totals and percents have been calculated on the basis of unrounded figures and therefore may not correspond exactly with those indicated by the rounded figures shown.

Appendix A

STATISTICAL TABLES

In the following tables, separate estimates are given for different industries and different sizes of companies wherever possible. The numbers of industries and other categories for which separate figures can be given are limited, however, by the necessity of keeping confidential the data supplied by individual companies, the size of the sample, and other technical factors. Several industries, consequently, have been combined into two residual groups—"other manufacturing industries" and "other nonmanufacturing industries." The former group includes the following industries: Rubber products, tobacco manufactures, lumber and wood products, furniture and fixtures, printing and publishing, leather, transportation equipment other than aircraft and motor vehicles, and miscellaneous manufacturing. The latter group includes: Mining; telecommunications; broadcasting; wholesale and retail trade; finance, insurance, and real estate; services; and agriculture, forestry, and fisheries.

All the absolute figures presented in the tables are rounded because they represent approximations only, being estimates based on sample data. All totals and percentages were, however, calculated on the basis of unrounded figures. They therefore do not always correspond exactly with those indicated by the rounded figures in the tables.

Percentages are shown to one decimal place to distinguish them from absolute figures and thus facilitate reading of the tables. The reader should bear in mind that the percentages, like the aggregate figures, are estimates subject to sampling error.

TABLE A–1.—*Scientists and engineers, by occupational group and industry, January 1960*

Industry	All groups	Engineers	Chemists	Physicists	Metallurgists	Geologists and geophysicists	Mathematicians	Medical scientists	Agricultural scientists	Biological scientists	Other scientists
	Number										
All industries	812, 700	648, 900	77, 000	15, 600	12, 700	15, 300	14, 100	6, 600	5, 900	7, 300	9, 200
Food and kindred products	9, 900	4, 500	3, 800	100	(1)	(1)	100	(1)	800	500	[2] 200
Textile mill products and apparel	5, 800	3, 800	1, 900	[2] 100	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Paper and allied products	10, 500	7, 100	2, 300	100	(1)	(1)	(1)	(1)	700	(1)	200
Chemicals and allied products	90, 700	38, 200	34, 100	1, 300	700	400	700	5, 300	2, 300	4, 700	3, 000
Petroleum products and extraction	48, 600	28, 700	6, 300	600	100	11, 800	600	(1)	200	(1)	400
Stone, clay, and glass products	10, 200	7, 900	1, 500	200	[2] 100	400	100	(1)	(1)	(1)	(1)
Primary metal industries	35, 100	25, 200	3, 800	200	5, 300	300	200	100	100	(1)	(1)
Fabricated metal products and ordnance	38, 100	34, 900	1, 700	300	300	(1)	800	(1)	100	(1)	100
Machinery (except electrical)	71, 400	64, 800	1, 600	900	1, 900	(1)	1, 100	[2] 100	(1)	(1)	1, 200
Electrical equipment	101, 400	91, 200	3, 300	4, 100	800	200	1, 800	(1)	(1)	(1)	(1)
Aircraft and parts	101, 500	84, 400	2, 800	5, 500	1, 400	100	3, 800	100	(1)	(1)	3, 400
Professional and scientific instruments	26, 300	22, 000	2, 400	900	200	(1)	200	200	(1)	200	200
Other manufacturing industries [3]	58, 100	50, 600	5, 300	500	700	(1)	100	(1)	400	(1)	(1)
Construction	45, 100	43, 200	500	(1)	[2] 200	100	[2] 800	(1)	100	[2] 200	[2] 200
Transportation and other public utilities	36, 700	34, 900	700	100	(1)	500	200	(1)	200	(1)	(1)
Engineering and architectural services	56, 900	54, 200	900	200	200	800	300	(1)	(1)	[2] 100	100
Other nonmanufacturing industries	66, 500	53, 500	4, 100	800	900	800	3, 100	[2] 700	1, 100	1, 300	[2] 200
	Percent distribution										
All industries	100. 0	100. 0	100. 0	100. 0	100. 0	100. 0	100. 0	100. 0	100. 0	100. 0	100. 0
Food and kindred products	1. 2	. 7	4. 9	. 4	(1)	(1)	. 4	(1)	13. 4	6. 3	[2] 2. 4
Textile mill products and apparel	. 7	. 6	2. 4	[2] . 8	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Paper and allied products	1. 3	1. 1	3. 0	. 6	(1)	(1)	(1)	(1)	12. 1	. 6	1. 7
Chemicals and allied products	11. 2	5. 9	44. 2	8. 4	5. 2	2. 3	5. 0	81. 2	38. 4	64. 8	33. 1
Petroleum products and extraction	6. 0	4. 4	8. 2	3. 6	. 6	76. 8	4. 1	(1)	2. 9	(1)	4. 2
Stone, clay, and glass products	1. 3	1. 2	2. 0	1. 2	[2] 1. 1	2. 5	. 6	(1)	(1)	(1)	(1)
Primary metal industries	4. 3	3. 9	5. 0	1. 1	41. 6	1. 8	1. 1	. 8	1. 5	(1)	(1)
Fabricated metal products and ordnance	4. 7	5. 4	2. 2	1. 7	2. 7	(1)	5. 4	. 1	1. 2	(1)	. 6
Machinery (except electrical)	8. 8	10. 0	2. 1	5. 6	14. 6	(1)	7. 5	[2] . 8	(1)	(1)	12. 5
Electrical equipment	12. 4	13. 9	4. 3	26. 1	6. 4	1. 4	12. 5	(1)	(1)	(1)	(1)
Aircraft and parts	12. 5	13. 0	3. 7	35. 4	10. 9	. 5	26. 9	1. 5	(1)	(1)	37. 0
Professional and scientific instruments	3. 2	3. 4	3. 1	5. 7	1. 3	(1)	1. 3	3. 5	(1)	3. 2	2. 5
Other manufacturing industries [3]	7. 1	7. 8	6. 9	2. 8	5. 3	(1)	4. 1	(1)	6. 4	(1)	(1)
Construction	5. 6	6. 7	. 6	(1)	[2] 1. 2	. 6	[2] 5. 6	(1)	. 9	[2] 2. 4	[2] 1. 7
Transportation and other public utilities	4. 5	5. 4	. 9	. 3	(1)	3. 5	1. 3	(1)	3. 0	(1)	(1)
Engineering and architectural services	7. 0	8. 4	1. 2	1. 4	1. 6	5. 4	1. 9	(1)	(1)	[2] 1. 6	. 7
Other nonmanufacturing industries	8. 2	8. 2	5. 3	4. 8	7. 1	4. 9	22. 1	[2] 11. 1	19. 1	18. 1	[2] 2. 6

[1] Less than 50 cases.
[2] Subject to a standard error of 50 percent or more.
[3] The motor vehicle and equipment industry has been included with "other manufacturing industries" for technical reasons in this and a number of other tables.

NOTE.—Totals and percents have been calculated on the basis of unrounded figures and therefore may not correspond exactly with those indicated by the rounded figures shown.

TABLE A-2.—*Scientists and engineers, by industry, January 1959 and January 1960, and percent change*

Industry	Number		Percent change [2]	Industry	Number		Percent change [2]
	January 1959 [1]	January 1960			January 1959 [1]	January 1960	
All industries	764, 100	812, 700	6. 4	Electrical equipment	92, 700	101, 400	9. 4
Food and kindred products	10, 200	9, 900	−2. 7	Aircraft and parts	94, 900	101, 500	7. 0
Textile mill products and apparel	5, 400	5, 800	8. 1	Professional and scientific instruments	23, 700	26, 300	11. 3
Paper and allied products	9, 700	10, 500	7. 9	Other manufacturing industries	53, 900	58, 100	7. 8
Chemicals and allied products	83, 100	90, 700	9. 0	Construction	43, 700	45, 100	3. 2
Petroleum products and extraction	47, 900	48, 600	1. 4	Transportation and other public utilities	35, 400	36, 700	3. 8
Stone, clay, and glass products	9, 200	10, 200	10. 3	Engineering and architectural services	56, 100	56, 900	1. 3
Primary metal industries	33, 200	35, 100	5. 7	Other nonmanufacturing industries	62, 900	66, 500	5. 7
Fabricated metal products and ordnance	34, 700	38, 100	9. 8				
Machinery (except electrical)	67, 400	71, 400	6. 0				

[1] Source: National Science Foundation, *Scientific and Technical Personnel in American Industry—Report on a 1959 Survey*—NSF 60-62 (U.S. Government Printing Office, Washington, 1960).
[2] See appendix C for standard errors of change.

NOTE.—Totals and percents have been calculated on the basis of unrounded figures and therefore may not correspond exactly with those indicated by the rounded figures shown.

TABLE A-3.—*Scientists and engineers as percent of total employment, by size of company and by industry, January 1960*

Industry	Scientists and engineers in all companies	Scientists and engineers in companies with total employment of—				
		Under 100	100–499	500–999	1,000–4,999	5,000 or more
All industries	2. 8	2. 2	1. 5	2. 2	2. 5	4. 1
Food and kindred products	. 7	. 3	. 4	. 7	1. 1	1. 1
Textile mill products and apparel	. 4	[1] . 2	. 3	. 4	. 4	. 7
Paper and allied products	1. 6	[1] . 2	. 6	. 8	2. 3	3. 2
Chemicals and allied products	9. 6	6. 4	6. 9	10. 0	9. 0	11. 0
Petroleum products and extraction	7. 7	3. 9	5. 5	8. 6	12. 3	8. 5
Stone, clay, and glass products	2. 0	1. 3	1. 2	1. 7	1. 9	2. 9
Primary metal industries	2. 5	1. 0	1. 4	1. 2	2. 4	3. 0
Fabricated metal products and ordnance	3. 3	3. 4	2. 1	1. 7	2. 5	5. 7
Machinery (except electrical)	4. 2	4. 2	4. 4	3. 6	4. 5	4. 1
Electrical equipment	7. 7	6. 0	5. 4	8. 5	5. 9	8. 8
Aircraft and parts	12. 0	3. 8	5. 2	9. 0	9. 4	12. 8
Professional and scientific instruments	7. 4	7. 9	6. 5	4. 8	7. 3	8. 0
Other manufacturing industries	1. 5	. 4	. 5	. 9	1. 1	2. 9
Construction	3. 1	2. 1	2. 9	4. 2	8. 1	12. 9
Transportation and other public utilities	1. 3	. 8	. 4	1. 0	2. 3	1. 3
Other nonmanufacturing industries [2]	1. 5	3. 1	1. 1	1. 7	. 7	1. 1

[1] Subject to a standard error of 50 percent or more.
[2] Engineering and architectural services have been included with "Other nonmanufacturing industries" for technical reasons in this and a number of other tables.

NOTE.—Employment estimates used in this table were derived from the survey and hence apply to the same industry and size of company categories as the estimates of scientists and engineers. See appendix B for a discussion of survey coverage.

TABLE A–4 —*Scientists and engineers, by size of company and by industry, January 1960*

Industry	All companies	Companies with total employment of—				
		Under 100	100–499	500–999	1,000–4,999	5,000 or more
	Number					
All industries	812,700	133,200	88,200	45,700	120,500	425,100
Food and kindred products	9,900	1,000	1,300	700	2,300	4,600
Textile mill products and apparel	5,800	[1] 400	1,600	700	1,300	1,800
Paper and allied products	10,500	[1] 400	800	400	3,700	5,200
Chemicals and allied products	90,700	8,300	6,300	5,500	15,500	55,100
Petroleum products and extraction	48,600	4,500	3,500	2,500	7,400	30,600
Stone, clay, and glass products	10,200	1,400	1,100	900	1,800	5,000
Primary metal industries	35,100	1,100	2,300	700	4,100	26,900
Fabricated metal products and ordnance	38,100	11,400	5,300	1,800	4,700	14,900
Machinery (except electrical)	71,400	14,600	12,900	4,300	15,600	24,100
Electrical equipment	101,400	7,700	7,200	8,200	13,800	64,600
Aircraft and parts	101,500	900	1,600	1,600	4,100	93,300
Professional and scientific instruments	26,300	4,700	3,700	1,000	6,800	10,100
Other manufacturing industries	58,100	3,000	4,400	2,700	6,400	41,600
Construction	45,100	18,000	11,400	3,100	8,600	4,100
Transportation and other public utilities	36,700	4,300	1,300	2,000	14,000	15,000
Other nonmanufacturing industries	123,400	51,500	23,600	9,700	10,300	28,300
	Percent distribution					
All industries	100.0	16.4	10.9	5.6	14.8	52.3
Food and kindred products	100.0	10.6	12.7	6.7	23.6	46.4
Textile mill products and apparel	100.0	[1] 6.9	27.7	11.4	22.9	31.1
Paper and allied products	100.0	[1] 3.6	7.2	4.2	35.5	49.5
Chemicals and allied products	100.0	9.2	6.9	6.1	17.1	60.7
Petroleum products and extraction	100.0	9.3	7.3	5.2	15.2	63.0
Stone, clay, and glass products	100.0	13.8	10.7	9.1	17.5	48.9
Primary metal industries	100.0	3.1	6.5	2.1	11.8	76.5
Fabricated metal products and ordnance	100.0	29.9	14.0	4.6	12.4	39.1
Machinery (except electrical)	100.0	20.4	18.1	6.0	21.9	33.6
Electrical equipment	100.0	7.6	7.1	8.1	13.6	63.6
Aircraft and parts	100.0	.9	1.6	1.6	4.0	91.9
Professional and scientific instruments	100.0	18.0	14.0	3.8	25.9	38.3
Other manufacturing industries	100.0	5.1	7.5	4.6	11.0	71.8
Construction	100.0	39.9	25.3	6.8	19.0	9.0
Transportation and other public utilities	100.0	11.8	3.6	5.6	38.2	40.8
Other nonmanufacturing industries	100.0	41.7	19.2	7.8	8.3	22.9

[1] Subject to a standard error of 50 percent or more.

NOTE.—Totals and percents have been calculated on the basis of unrounded figures and therefore may not correspond exactly with those indicated by the rounded figures shown.

TABLE A–5.—*Scientists and engineers, by size of company and by occupational group, January 1960*

Occupational group	All companies	Companies with total employment of—				
		Under 100	100–499	500–999	1,000–4,999	5,000 or more
	Number					
All groups	812,700	133,200	88,200	45,700	120,500	425,100
Engineers	648,900	114,300	72,800	35,800	93,800	332,300
Chemists	77,000	9,800	8,300	4,900	13,100	40,900
Physicists	15,600	600	600	300	1,000	13,100
Metallurgists	12,700	1,500	1,500	600	1,900	7,300
Geologists and geophysicists	15,300	2,600	1,700	1,500	2,900	6,600
Mathematicians	14,100	1,300	1,500	500	1,500	9,300
Medical scientists	6,600	800	100	100	1,100	4,400
Agricultural scientists	5,900	900	1,100	200	1,300	2,500
Biological scientists	7,300	1,400	300	700	2,100	2,900
Other scientists	9,200	[1] 200	[1] 400	1,000	1,900	5,700
	Percent distribution					
All groups	100.0	16.4	10.9	5.6	14.8	52.3
Engineers	100.0	17.6	11.2	5.5	14.4	51.3
Chemists	100.0	12.7	10.8	6.4	17.0	53.1
Physicists	100.0	3.9	3.8	2.2	6.1	84.0
Metallurgists	100.0	11.5	11.7	4.9	14.7	57.2
Geologists and geophysicists	100.0	17.0	11.2	9.9	18.7	43.2
Mathematicians	100.0	9.2	10.3	3.5	10.9	66.1
Medical scientists	100.0	12.6	2.1	2.2	16.5	66.1
Agricultural scientists	100.0	14.5	18.2	2.6	21.7	43.0
Biological scientists	100.0	18.8	3.9	9.1	28.2	40.0
Other scientists	100.0	[1] 2.0	[1] 4.2	11.2	21.1	61.5

[1] Subject to a standard error of 50 percent or more.

NOTE.—Totals and percents have been calculated on the basis of unrounded figures and therefore may not correspond exactly with those indicated by the rounded figures shown.

TABLE A–6.—*Scientists and engineers, by function and occupational group, January 1960*

Occupational group	All scientists and engineers	Scientists and engineers primarily engaged in—					
		Research and development	Management and administration of—		Exploration	Production and operations	All other activities
			Research and development	Other activities			
	Number						
All groups	812,700	257,100	45,400	67,700	14,400	310,000	118,000
Engineers	648,900	190,400	33,800	58,400	2,400	268,800	95,100
Chemists	77,000	35,700	7,200	4,200	200	23,200	6,600
Physicists	15,600	12,300	1,600	300	100	900	400
Metallurgists	12,700	5,300	900	1,100	(1)	4,700	600
Geologists and geophysicists	15,300	600	200	900	11,500	1,600	500
Mathematicians	14,100	7,000	700	600	100	3,700	2,000
Medical scientists	6,600	1,000	300	400	(1)	700	4,200
Agricultural scientists	5,900	1,100	200	900	(1)	1,900	1,800
Biological scientists	7,300	3,600	400	300	(1)	1,200	1,800
Other scientists	9,200	400	(1)	600	(1)	3,300	4,900
	Percent distribution						
All groups	100.0	31.6	5.6	8.3	1.8	38.2	14.5
Engineers	100.0	29.3	5.2	9.0	.4	41.4	14.7
Chemists	100.0	46.3	9.3	5.4	.3	30.2	8.5
Physicists	100.0	78.6	10.0	2.1	.5	5.9	2.9
Metallurgists	100.0	41.7	7.2	8.7	(1)	37.0	5.0
Geologists and geophysicists	100.0	3.8	1.5	5.9	75.3	10.3	3.2
Mathematicians	100.0	49.8	4.8	4.3	.6	26.5	14.0
Medical scientists	100.0	15.0	4.5	5.9	(1)	10.5	64.1
Agricultural scientists	100.0	17.8	3.6	15.9	(1)	31.1	31.0
Biological scientists	100.0	49.2	5.5	4.2	(1)	16.8	24.1
Other scientists	100.0	3.8	(1)	6.0	(1)	36.3	53.4

[1] Less than 50 cases.

NOTE.—Totals and percents have been calculated on the basis of unrounded figures and therefore may not correspond exactly with those indicated by the rounded figures shown.

TABLE A–7.—*Scientists and engineers, by function and industry, January 1960*

Industry	All scientists and engineers	Scientists and engineers primarily engaged in—					
		Research and development	Management and administration of—		Exploration	Production and operations	All other activities
			Research and development	Other activities			
	Number						
All industries	812, 700	257, 100	45, 400	67, 700	14, 400	310, 000	118, 000
Food and kindred products	9, 900	3, 000	700	1, 000	(1)	4, 900	400
Textile mill products and apparel	5, 800	1, 500	300	300	(1)	3, 500	200
Paper and allied products	10, 500	2, 600	700	800	(1)	5, 300	1, 100
Chemicals and allied products	90, 700	31, 800	4, 800	5, 700	400	27, 800	20, 100
Petroleum products and extraction	48, 600	8, 100	1, 200	4, 900	11, 200	16, 800	6, 400
Stone, clay, and glass products	10, 200	2, 500	1, 000	800	100	4, 800	1, 000
Primary metal industries	35, 100	4, 900	1, 200	4, 700	300	19, 400	4, 800
Fabricated metal products and ordnance	38, 100	13, 000	2, 400	2, 800	(1)	14, 800	4, 900
Machinery (except electrical)	71, 400	22, 000	6, 300	6, 200	100	23, 000	14, 000
Electrical equipment	101, 400	54, 900	7, 700	4, 700	500	19, 600	13, 900
Aircraft and parts	101, 500	58, 800	5, 800	3, 600	(1)	28, 800	4, 500
Professional and scientific instruments	26, 300	12, 100	2, 000	1, 400	(1)	6, 700	4, 000
Other manufacturing industries	58, 100	20, 400	5, 700	3, 600	100	24, 500	3, 800
Construction	45, 100	1, 300	700	6, 200	100	29, 200	7, 600
Transportation and other public utilities	36, 700	1, 200	400	5, 800	400	23, 600	5, 200
Engineering and architectural services	56, 900	6, 400	1, 900	5, 800	800	29, 700	12, 200
Other nonmanufacturing industries	66, 500	12, 800	2, 600	9, 400	300	27, 500	13, 800
	Percent distribution						
All industries	100. 0	31. 6	5. 6	8. 3	1. 8	38. 2	14. 5
Food and kindred products	100. 0	29. 9	6. 6	9. 8	(1)	49. 2	4. 4
Textile mill products and apparel	100. 0	25. 5	4. 5	5. 0	(1)	61. 2	3. 8
Paper and allied products	100. 0	24. 7	6. 4	7. 6	(1)	50. 5	10. 5
Chemicals and allied products	100. 0	35. 1	5. 3	6. 3	. 5	30. 6	22. 2
Petroleum products and extraction	100. 0	16. 6	2. 5	10. 0	23. 1	34. 6	13. 2
Stone, clay, and glass products	100. 0	24. 5	9. 8	7. 9	1. 4	46. 6	9. 8
Primary metal industries	100. 0	13. 8	3. 3	13. 5	. 7	55. 2	13. 5
Fabricated metal products and ordnance	100. 0	34. 1	6. 3	7. 5	(1)	39. 0	12. 8
Machinery (except electrical)	100. 0	30. 7	8. 8	8. 6	. 1	32. 3	19. 5
Electrical equipment	100. 0	54. 2	7. 6	4. 7	. 5	19. 2	13. 8
Aircraft and parts	100. 0	58. 0	5. 7	3. 5	(1)	28. 4	4. 4
Professional and scientific instruments	100. 0	45. 9	7. 7	5. 4	(1)	25. 5	15. 2
Other manufacturing industries	100. 0	35. 1	9. 8	6. 2	. 2	42. 1	6. 6
Construction	100. 0	2. 9	1. 6	13. 7	. 2	64. 7	16. 9
Transportation and other public utilities	100. 0	3. 3	1. 2	15. 9	1. 2	64. 3	14. 1
Engineering and architectural services	100. 0	11. 3	3. 4	10. 1	1. 4	52. 3	21. 5
Other nonmanufacturing industries	100. 0	19. 3	3. 9	14. 2	. 5	41. 3	20. 8

[1] Less than 50 cases.

NOTE.—Totals and percents have been calculated on the basis of unrounded figures and therefore may not correspond exactly with those indicated by the rounded figures shown.

TABLE A–8.—*Scientists and engineers, by function and size of company, January 1960*

Size of company	All scientists and engineers	Scientists and engineers primarily engaged in—					
		Research and development	Management and administration of—		Exploration	Production and operations	All other activities
			Research and development	Other activities			
	Number						
All sizes	812, 700	257, 100	45, 400	67, 700	14, 400	310, 000	118, 000
Under 100 employees	133, 200	17, 300	8, 700	15, 400	2, 300	71, 300	18, 100
100–499 employees	88, 200	19, 400	5, 900	7, 700	2, 000	38, 500	14, 700
500–999 employees	45, 700	11, 500	2, 800	4, 000	1, 400	16, 300	9, 700
1,000–4,999 employees	120, 500	32, 100	5, 900	11, 900	3, 000	43, 300	24, 200
5,000 or more employees	425, 100	176, 800	22, 000	28, 700	5, 700	140, 600	51, 300
	Percent distribution						
All sizes	100. 0	31. 6	5. 6	8. 3	1. 8	38. 2	14. 5
Under 100 employees	100. 0	13. 0	6. 5	11. 6	1. 7	53. 6	13. 6
100–499 employees	100. 0	22. 1	6. 6	8. 8	2. 3	43. 5	16. 7
500–999 employees	100. 0	25. 1	6. 2	8. 7	3. 1	35. 7	21. 2
1,000–4,999 employees	100. 0	26. 7	4. 9	9. 8	2. 5	36. 0	20. 1
5,000 or more employees	100. 0	41. 6	5. 2	6. 7	1. 3	33. 1	12. 1

NOTE.—Totals and percents have been calculated on the basis of unrounded figures and therefore may not correspond exactly with those indicated by the rounded figures shown.

TABLE A–9.—*Scientists and engineers primarily engaged in research and development as percent of scientists and engineers in all activities, by occupational group and industry, January 1960* [1]

Industry	All groups	Engineers	Chemists	Physicists	Metallurgists	Geologists and geophysicists	Mathematicians	Medical scientists	Agricultural scientists	Biological scientists	Other scientists
All industries	37.2	34.6	55.6	88.6	49.0	5.3	54.7	19.5	21.4	54.7	4.3
Food and kindred products	36.5	25.9	44.4	100.0	(2)	(2)	(2)	(2)	36.8	71.6	(2)
Textile mill products and apparel	30.0	21.6	45.6	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Paper and allied products	31.1	24.8	56.9	68.8	(2)	(2)	(2)	(2)	10.2	(2)	(2)
Chemicals and allied products	40.4	27.3	57.3	78.7	68.9	(2)	49.4	18.8	25.3	66.8	2.5
Petroleum products and extraction	19.1	17.0	51.6	73.7	(2)	3.5	39.1	(2)	[3] 33.3	(2)	(2)
Stone, clay, and glass products	34.3	29.6	58.2	90.8	(2)	(2)	61.2	(2)	(2)	(2)	(2)
Primary metal industries	17.1	11.7	34.8	77.1	28.3	(2)	(2)	(2)	(2)	(2)	(2)
Fabricated metal products and ordnance	40.4	39.3	48.1	99.3	55.6	(2)	66.1	(2)	(2)	(2)	(2)
Machinery (except electrical)	39.5	38.0	71.3	79.6	65.9	(2)	45.7	(2)	(2)	(2)	(2)
Electrical equipment	61.8	59.4	79.2	92.0	83.9	(2)	80.5	(2)	(2)	(2)	(2)
Aircraft and parts	63.7	62.8	70.9	93.9	79.9	98.8	81.6	86.7	(2)	(2)	1.7
Professional and scientific instruments	53.6	51.6	62.2	84.4	58.6	(2)	74.2	48.9	(2)	48.9	34.5
Other manufacturing industries	44.9	42.0	66.5	74.4	64.0	(2)	71.9	(2)	21.5	(2)	(2)
Construction	4.5	[3] 3.7	58.1	(2)	[3] 60.6	(2)	(2)	(2)	(2)	(2)	(2)
Transportation and other public utilities	4.5	4.1	15.1	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Engineering and architectural services	14.7	13.7	45.8	89.6	[3] 30.3	(2)	42.9	(2)	(2)	52.6	(2)
Other nonmanufacturing industries	23.2	21.5	39.4	94.3	34.7	20.6	25.1	(2)	9.8	12.1	(2)

[1] Includes both scientists and engineers conducting and those administering research and development.
[2] Less than 50 cases.
Subject to a standard error of 50 percent or more.

NOTE.—Percents have been calculated on the basis of unrounded figures and therefore may not correspond exactly with those indicated by the rounded figures shown.

TABLE A–10.—*Scientists and engineers primarily engaged in research and development, by occupational group and industry, January 1960* [1]

Industry	All groups	Engineers	Chemists	Physicists	Metallurgists	Geologists and geophysicists	Mathematicians	Medical scientists	Agricultural scientists	Biological scientists	Other scientists
All industries	302, 500	224, 300	42, 800	13, 800	6, 200	800	7, 700	1, 300	1, 300	4, 000	400
Food and kindred products	3, 600	1, 200	1, 700	100	(2)	(2)	(2)	(2)	300	300	(2)
Textile mill products and apparel	1, 700	800	900	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Paper and allied products	3, 300	1, 800	1, 300	100	(2)	(2)	(2)	(2)	100	(2)	(2)
Chemicals and allied products	36, 600	10, 400	19, 500	1, 000	500	(2)	300	1, 000	600	3, 200	100
Petroleum products and extraction	9, 300	4, 900	3, 200	400	(2)	400	200	(2)	[3] 100	(2)	(2)
Stone, clay, and glass products	3, 500	2, 300	900	200	(2)	(2)	100	(2)	(2)	(2)	(2)
Primary metal industries	6, 000	3, 000	1, 300	100	1, 500	(2)	(2)	(2)	(2)	(2)	(2)
Fabricated metal products and ordnance	15, 400	13, 700	800	300	200	(2)	500	(2)	(2)	(2)	(2)
Machinery (except electrical)	28, 200	24, 600	1, 200	700	1, 200	(2)	500	(2)	(2)	(2)	(2)
Electrical equipment	62, 600	54, 200	2, 600	3, 800	700	(2)	1, 400	(2)	(2)	(2)	(2)
Aircraft and parts	64, 600	52, 900	2, 000	5, 200	1, 100	100	3, 100	100	(2)	(2)	100
Professional and scientific instruments	14, 100	11, 300	1, 500	800	100	(2)	100	[3] 100	(2)	100	100
Other manufacturing industries	26, 100	21, 200	3, 600	300	400	(2)	400	(2)	100	(2)	(2)
Construction	2, 000	[3] 1, 600	300	(2)	[3] 100	(2)	(2)	(2)	(2)	(2)	(2)
Transportation and other public utilities	1, 600	1, 400	100	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Engineering and architectural services	8, 300	7, 400	400	200	[3] 100	(2)	100	(2)	(2)	100	(2)
Other nonmanufacturing industries	15, 400	11, 500	1, 600	700	300	200	800	(2)	100	200	(2)

[1] Includes both scientists and engineers conducting and those administering research and development.
[2] Less than 50 cases.
[3] Subject to a standard error of 50 percent or more.

NOTE.—Totals have been calculated on the basis of unrounded figures and therefore may not correspond exactly with those indicated by the rounded figures shown.

TABLE A-11.—*Scientists and engineers primarily engaged in research and development, by size of company and by industry January 1960* [1]

Industry	All companies	Companies with total employment of—				
		Under 100	100–499	500–999	1,000–4,999	5,000 or more
	Number					
All industries	302, 500	26, 000	25, 300	14, 300	38, 100	198, 800
Food and kindred products	3, 600	(2)	[3] 200	[3] 300	800	2, 400
Textile mill products and apparel	1, 700	(2)	[3] 600	(2)	400	700
Paper and allied products	3, 300	[3] 400	[3] 100	[3] 100	1, 100	1, 600
Chemicals and allied products	36, 600	3, 600	3, 000	2, 300	6, 800	21, 100
Petroleum products and extraction	9, 300	[3] 700	[3] 200	300	2, 000	6, 000
Stone, clay, and glass products	3, 500	[3] 700	[3] 300	[3] 300	500	1, 700
Primary metal industries	6, 000	[3] 100	500	[3] 100	1, 200	4, 200
Fabricated metal products and ordnance	15, 400	2, 100	1, 500	500	2, 200	9, 200
Machinery (except electrical)	28, 200	4, 800	4, 700	1, 000	5, 300	12, 400
Electrical equipment	62, 600	3, 500	3, 900	5, 100	5, 600	44, 600
Aircraft and parts	64, 600	[3] 300	700	800	1, 800	61, 000
Professional and scientific instruments	14, 100	[3] 2, 400	2, 200	400	3, 500	5, 600
Other manufacturing industries	26, 100	700	[3] 1, 800	800	2, 600	20, 100
Construction	2, 000	[3] 1, 000	[3] 300	100	300	400
Transportation and other public utilities	1, 600	(2)	(2)	100	600	800
Other nonmanufacturing industries	23, 700	5, 800	5, 300	2, 200	3, 500	7, 100
	Percent of scientists and engineers in all activities					
All industries	37. 2	19. 5	28. 7	31. 3	31. 6	46. 8
Food and kindred products	36. 5	(2)	[3] 16. 1	[3] 37. 8	33. 2	51. 8
Textile mill products and apparel	30. 0	(2)	[3] 36. 9	(2)	33. 9	36. 6
Paper and allied products	31. 1	[3] 100. 0	[3] 16. 8	[3] 23. 3	28. 5	30. 8
Chemicals and allied products	40. 4	42. 6	47. 3	40. 8	43. 6	38. 3
Petroleum products and extraction	19. 1	[3] 16. 3	[3] 6. 7	11. 2	27. 2	19. 7
Stone, clay, and glass products	34. 3	[3] 50. 0	[3] 27. 3	[3] 31. 6	26. 9	34. 5
Primary metal industries	17. 1	[3] 9. 1	20. 1	[3] 14. 2	27. 9	15. 6
Fabricated metal products and ordnance	40. 4	18. 1	27. 9	27. 7	46. 8	61. 4
Machinery (except electrical)	39. 5	32. 9	36. 3	24. 6	33. 8	51. 6
Electrical equipment	61. 8	45. 7	54. 4	62. 2	40. 6	69. 0
Aircraft and parts	63. 7	[3] 38. 5	43. 1	47. 0	43. 7	65. 4
Professional and scientific instruments	53. 6	[3] 51. 6	60. 2	36. 8	50. 6	55. 7
Other manufacturing industries	44. 9	22. 1	[3] 42. 3	31. 6	41. 0	48. 3
Construction	4. 5	[3] 5. 3	[3] 2. 2	2. 7	3. 9	9. 6
Transportation and other public utilities	4. 5	(2)	(2)	7. 1	4. 5	5. 5
Other nonmanufacturing industries	19. 2	11. 2	22. 3	22. 4	33. 6	25. 0

[1] Includes both scientists and engineers conducting and those administering research and development.
[2] Less than 50 cases.
[3] Subject to a standard error of 50 percent or more.

NOTE.—Totals and percents have been calculated on the basis of unrounded figures and therefore may not correspond exactly with those indicated by the rounded figures shown.

TABLE A-12.—*Scientists and engineers primarily engaged in research and development, by size of company and by occupational group, January 1960* [1]

Occupational group	All companies	Companies with total employment of—				
		Under 100	100–499	500–999	1,000–4,999	5,000 or more
	Number					
All groups	302, 500	26, 000	25, 300	14, 300	38, 100	198, 800
Engineers	224, 300	19, 400	19, 200	10, 300	25, 900	149, 400
Chemists	42, 800	4, 700	4, 400	2, 600	7, 200	24, 000
Physicists	13, 800	500	400	300	800	11, 800
Metallurgists	6, 200	[2] 900	500	200	800	3, 800
Geologists and geophysicists	800	200	[3]	[3]	200	400
Mathematicians	7, 700	200	300	200	600	6, 300
Medical scientists	1, 300	[2] 100	[2] 100	100	600	400
Agricultural scientists	1, 300	[2] 100	[2] 200	[2] 100	300	600
Biological scientists	4, 000	100	200	400	1, 400	1, 900
Other scientists	400	[3]	[3]	[3]	[3]	300
	Percent of scientists and engineers in all activities					
All groups	37. 2	19. 5	28. 7	31. 3	31. 6	46. 8
Engineers	34. 6	17. 0	26. 3	28. 8	27. 7	45. 0
Chemists	55. 6	48. 3	52. 6	52. 4	55. 1	58. 6
Physicists	88. 6	76. 6	74. 5	90. 7	85. 3	89. 9
Metallurgists	49. 0	[2] 60. 6	35. 1	35. 5	42. 1	52. 5
Geologists and geophysicists	5. 3	6. 0	[3]	[3]	5. 3	6. 4
Mathematicians	54. 7	17. 9	21. 8	45. 3	41. 1	67. 6
Medical scientists	19. 5	[2] 9. 4	[2] 42. 6	54. 4	59. 2	9. 7
Agricultural scientists	21. 4	[2] 7. 4	[2] 15. 1	[2] 60. 4	25. 3	24. 6
Biological scientists	54. 7	7. 2	57. 6	65. 9	68. 2	64. 6
Other scientists	4. 3	[3]	[3]	[3]	[3]	5. 6

[1] Includes both scientists and engineers conducting and those administering research and development.
[2] Subject to a standard error of 50 percent or more.
[3] Less than 50 cases.

NOTE.—Totals and percents have been calculated on the basis of unrounded figures and therefore may not correspond exactly with those indicated by the rounded figures shown.

TABLE A–13.—*Engineers, by function and industry, January 1960*

Industry	Total engineers	Engineers primarily engaged in—					
		Research and development	Management and administration of—		Exploration	Production and operations	All other activities
			Research and development	Other activities			
All industries	648, 900	190, 400	33, 800	58, 400	2, 400	268, 800	95, 100
Food and kindred products	4, 500	1, 000	200	400	(1)	2, 700	200
Textile mill products and apparel	3, 800	700	100	200	(1)	2, 600	200
Paper and allied products	7, 100	1, 300	500	600	(1)	4, 000	800
Chemicals and allied products	38, 200	9, 100	1, 300	3, 100	100	17, 000	7, 600
Petroleum products and extraction	28, 700	4, 200	700	3, 600	1, 300	14, 000	4, 800
Stone, clay, and glass products	7, 900	1, 600	800	800	(1)	3, 800	900
Primary metal industries	25, 200	2, 300	600	3, 700	100	14, 400	4, 100
Fabricated metal products and ordnance	34, 900	11, 600	2, 200	2, 700	(1)	13, 900	4, 600
Machinery (except electrical)	64, 800	19, 200	5, 400	5, 800	(1)	21, 900	12, 400
Electrical equipment	91, 200	47, 400	6, 700	4, 500	300	18, 700	13, 500
Aircraft and parts	84, 400	47, 800	5, 100	3, 400	(1)	24, 500	3, 500
Professional and scientific instruments	22, 000	9, 700	1, 600	1, 300	(1)	5, 900	3, 500
Other manufacturing industries	50, 600	16, 800	4, 500	3, 200	(1)	22, 400	3, 700
Construction	43, 200	1, 000	700	6, 000	(1)	28, 100	7, 400
Transportation and other public utilities	34, 900	1, 100	400	5, 600	100	22, 900	4, 900
Engineering and architectural services	54, 200	5, 700	1, 700	5, 300	200	29, 200	12, 100
Other nonmanufacturing industries	53, 500	10, 000	1, 500	8, 100	100	22, 700	11, 000

[1] Less than 50 cases.

NOTE.—Totals have been calculated on the basis of unrounded figures and therefore may not correspond exactly with those indicated by the rounded figures shown.

TABLE A–14.—*Scientists and engineers primarily engaged in research and development compared with full-time equivalent number of research and development scientists and engineers, by industry, January 1960* [1]

Industry	Scientists and engineers primarily engaged in research and development	Full-time equivalent scientists and engineers in research and development		Industry	Scientists and engineers primarily engaged in research and development	Full-time equivalent scientists and engineers in research and development	
		Number	Percent primarily engaged in research and development			Number	Percent primarily engaged in research and development
All industries	302, 500	286, 200	94. 6	Machinery (except electrical)	28, 200	23, 800	84. 4
Food and kindred products	3, 600	3, 000	82. 9	Electrical equipment	62, 600	62, 300	99. 4
Textile mill products and apparel	1, 700	1, 400	80. 6	Aircraft and parts	64, 600	64, 600	100. 0
Paper and allied products	3, 300	2, 900	88. 7	Professional and scientific instruments	14, 100	12, 100	86. 0
Chemicals and allied products	36, 600	36, 100	98. 5	Other manufacturing industries	26, 100	24, 300	93. 1
Petroleum products and extraction	9, 300	8, 900	95. 4	Construction	2, 000	1, 900	95. 4
Stone, clay, and glass products	3, 500	2, 900	83. 2	Transportation and other public utilities	1, 600	1, 100	67. 0
Primary metal industries	6, 000	5, 400	89. 4	Engineering and architectural services	8, 300	6, 900	82. 6
Fabricated metal products and ordnance	15, 400	13, 300	86. 1	Other nonmanufacturing industries	15, 400	14, 800	95. 9

[1] Includes both scientists and engineers conducting and those administering research and development.

NOTE.—Totals and percents have been calculated on the basis of unrounded figures and therefore may not correspond exactly with those indicated by the rounded figures shown.

TABLE A–15.—*Technicians, by occupational group and industry, January 1960*

Industry	All groups	Draftsmen	Engineering and physical science technicians	Medical, agricultural, and biological technicians	Other technicians
	Number				
All industries	593, 600	210, 000	284, 600	16, 100	82, 900
Food and kindred products	8, 100	1, 000	2, 100	1, 100	3, 800
Textile mill products and apparel	4, 700	600	2, 200	(1)	2, 000
Paper and allied products	6, 500	1, 100	3, 200	100	2, 100
Chemicals and allied products	39, 500	3, 900	23, 300	4, 000	8, 200
Petroleum products and extraction	18, 100	5, 500	11, 200	200	1, 200
Stone, clay, and glass products	5, 000	1, 600	2, 900	(1)	500
Primary metal industries	17, 900	5, 800	9, 400	200	2, 600
Fabricated metal products and ordnance	37, 800	19, 200	13, 800	100	4, 700
Machinery (except electrical)	72, 100	29, 200	33, 900	200	8, 800
Electrical equipment	79, 200	28, 800	44, 700	100	5, 600
Aircraft and parts	46, 800	14, 600	29, 500	100	2, 600
Professional and scientific instruments	21, 300	6, 200	10, 000	500	4, 600
Other manufacturing industries	52, 500	21, 300	22, 600	400	8, 200
Construction	26, 800	13, 600	9, 200	100	3, 900
Transportation and other public utilities	27, 000	7, 000	10, 800	400	8, 900
Engineering and architectural services	63, 500	41, 000	16, 100	[2] 200	6, 200
Other nonmanufacturing industries	66, 800	9, 600	39, 700	8, 400	9, 100
	Percent distribution				
All industries	100. 0	100. 0	100. 0	100. 0	100. 0
Food and kindred products	1. 4	. 5	. 7	7. 1	4. 6
Textile mill products and apparel	. 8	. 3	. 8	(1)	2. 4
Paper and allied products	1. 1	. 5	1. 1	. 6	2. 5
Chemicals and allied products	6. 7	1. 9	8. 2	24. 8	9. 9
Petroleum products and extraction	3. 1	2. 6	3. 9	1. 2	1. 4
Stone, clay, and glass products	. 8	. 7	1. 0	(1)	. 6
Primary metal industries	3. 0	2. 7	3. 3	1. 4	3. 1
Fabricated metal products and ordnance	6. 4	9. 2	4. 8	. 5	5. 7
Machinery (except electrical)	12. 1	13. 9	11. 9	1. 5	10. 7
Electrical equipment	13. 2	13. 7	15. 9	. 7	6. 7
Aircraft and parts	7. 9	6. 9	10. 4	. 6	3. 1
Professional and scientific instruments	3. 6	2. 9	3. 5	2. 9	5. 6
Other manufacturing industries	8. 8	10. 1	7. 9	2. 5	9. 9
Construction	4. 5	6. 5	3. 2	. 5	4. 7
Transportation and other public utilities	4. 6	3. 3	3. 8	2. 3	10. 7
Engineering and architectural services	10. 7	19. 7	5. 7	[2] 1. 0	7. 4
Other nonmanufacturing industries	11. 3	4. 6	13. 9	52. 4	11. 0

[1] Less than 50 cases.
[2] Subject to a standard error of 50 percent or more.

NOTE.—Totals and percents have been calculated on the basis of unrounded figures and therefore may not correspond exactly with those indicated by the rounded figures shown.

TABLE A–16.—*Technicians, by industry, January 1959 and January 1960, and percent change*

Industry	Number		Percent change[2]	Industry	Number		Percent change[2]
	January 1959[1]	January 1960			January 1959[1]	January 1960	
All industries	549, 400	593, 600	8. 1	Motor vehicles and equipment	25, 300	24, 500	−3. 2
				Aircraft and parts	52, 500	46, 800	−10. 9
Food and kindred products	5, 200	8, 100	53. 9	Professional and scientific instruments	19, 600	21, 300	9. 0
Textile mill products and apparel	3, 900	4, 700	22. 1	Other manufacturing industries	26, 900	28, 000	4. 0
Paper and allied products	6, 100	6, 500	5. 4	Construction	21, 200	26, 800	26. 5
Chemicals and allied products	34, 400	39, 500	14. 9	Transportation and other public utilities	25, 100	27, 000	7. 7
Petroleum products and extraction	18, 200	18, 100	−. 3	Engineering and architectural services	62, 300	63, 500	1. 9
Stone, clay, and glass products	4, 500	5, 000	9. 8	Other nonmanufacturing industries	60, 300	66, 800	10. 8
Primary metal industries	16, 900	17, 900	6. 4				
Fabricated metal products and ordnance	34, 200	37, 800	10. 6				
Machinery (except electrical)	65, 400	72, 100	10. 3				
Electrical equipment	67, 400	79, 200	17. 5				

[1] Source: National Science Foundation, *Scientific and Technical Personnel in American Industry—Report on a 1959 Survey*—NSF 60–62 (U.S. Government Printing Office, Washington, 1960).

[2] See appendix C for standard error of change.

NOTE.—Totals and percents have been calculated on the basis of unrounded figures and therefore may not correspond exactly with those indicated by the rounded figures shown.

TABLE A–17.—*Technicians, by size of company and by industry, January 1960*

Industry	All companies	Companies with total employment of—				
		Under 100	100–499	500–999	1,000–4,999	5,000 or more
	Number					
All industries	593, 600	145, 400	81, 000	33, 700	72, 200	261, 300
Food and kindred products	8, 100	2, 100	1, 300	800	1, 200	2, 600
Textile mill products and apparel	4, 700	[1] 900	600	700	1, 000	1, 500
Paper and allied products	6, 500	[1] 1, 200	400	[1] 100	2, 400	2, 400
Chemicals and allied products	39, 500	5, 100	3, 200	2, 100	5, 700	23, 500
Petroleum products and extraction	18, 100	800	[1] 1, 700	1, 400	3, 700	10, 500
Stone, clay, and glass products	5, 000	600	800	500	1, 000	2, 100
Primary metal industries	17, 900	[1] 300	1, 700	700	2, 600	12, 600
Fabricated metal products and ordnance	37, 800	14, 400	6, 100	2, 100	4, 100	11, 200
Machinery (except electrical)	72, 100	12, 100	11, 600	4, 100	10, 000	34, 200
Electrical equipment	79, 200	9, 000	6, 600	7, 500	9, 500	46, 700
Motor vehicles and equipment	24, 500	300	500	500	1, 000	22, 300
Aircraft and parts	46, 800	[1] 400	1, 100	900	1, 700	42, 700
Professional and scientific instruments	21, 300	7, 300	3, 700	600	4, 500	5, 200
Other manufacturing industries	28, 000	[1] 3, 200	4, 600	1, 000	4, 300	14, 900
Construction	26, 800	[1] 9, 200	8, 700	4, 000	3, 200	1, 600
Transportation and other public utilities	27, 000	6, 500	800	1, 100	8, 200	10, 400
Other nonmanufacturing industries	130, 300	72, 100	27, 700	5, 400	8, 300	16, 900
	Percent distribution					
All industries	100. 0	24. 5	13. 6	5. 7	12. 2	44. 0
Food and kindred products	100. 0	26. 6	16. 5	10. 4	14. 6	31. 9
Textile mill products and apparel	100. 0	[1] 19. 2	12. 2	15. 2	21. 2	32. 2
Paper and allied products	100. 0	[1] 18. 3	6. 2	[1] 2. 3	36. 7	36. 5
Chemicals and allied products	100. 0	12. 8	8. 0	5. 4	14. 4	59. 4
Petroleum products and extraction	100. 0	4. 7	[1] 9. 4	7. 8	20. 2	57. 9
Stone, clay, and glass products	100. 0	11. 1	17. 0	9. 5	19. 9	42. 5
Primary metal industries	100. 0	[1] 1. 6	9. 4	4. 1	14. 5	70. 4
Fabricated metal products and ordnance	100. 0	38. 0	16. 0	5. 7	10. 8	29. 5
Machinery (except electrical)	100. 0	16. 8	16. 1	5. 7	13. 8	47. 6
Electrical equipment	100. 0	11. 4	8. 3	9. 5	11. 9	58. 9
Motor vehicles and equipment	100. 0	1. 1	2. 1	1. 9	4. 0	90. 9
Aircraft and parts	100. 0	[1] . 8	2. 4	1. 8	3. 6	91. 4
Professional and scientific instruments	100. 0	34. 0	17. 1	3. 0	21. 3	24. 6
Other manufacturing industries	100. 0	[1] 11. 6	16. 3	3. 5	15. 3	53. 3
Construction	100. 0	[1] 34. 3	32. 4	15. 1	12. 0	6. 2
Transportation and other public utilities	100. 0	24. 0	3. 0	4. 2	30. 5	38. 3
Other nonmanufacturing industries	100. 0	55. 4	21. 2	4. 1	6. 3	13. 0

[1] Subject to a standard error of 50 percent or more.

NOTE.—Totals and percents have been calculated on the basis of unrounded figures and therefore may not correspond exactly with those indicated by the rounded figures shown.

TABLE A–18.—*Technicians, by size of company and by occupational group, January 1960*

Size of company	All groups	Draftsmen	Engineering and physical science technicians	Medical, agricultural, and biological technicians	All other technicians
	Number				
All sizes	593, 600	210, 000	284, 600	16, 100	82, 900
Under 100 employees	145, 400	56, 100	49, 900	7, 800	31, 600
100–499 employees	81, 000	36, 800	32, 200	1, 900	10, 100
500–999 employees	33, 700	14, 300	13, 400	900	5, 200
1,000–4,999 employees	72, 200	28, 500	33, 300	2, 000	8, 300
5,000 or more employees	261, 300	74, 300	155, 800	3, 600	27, 700
	Percent distribution				
All sizes	100. 0	100. 0	100. 0	100. 0	100. 0
Under 100 employees	24. 5	26. 7	17. 6	48. 3	38. 1
100–499 employees	13. 6	17. 5	11. 3	11. 7	12. 2
500–999 employees	5. 7	6. 8	4. 7	5. 7	6. 3
1,000–4,999 employees	12. 2	13. 6	11. 7	12. 2	10. 0
5,000 or more employees	44. 0	35. 4	54. 7	22. 1	33. 4

NOTE.—Totals and percents have been calculated on the basis of unrounded figures and therefore may not correspond exactly with those indicated by the rounded figures shown.

TABLE A–19.—*Technicians primarily engaged in research and development, by industry, January 1960*

Industry	Total technicians	Research and development technicians		Industry	Total technicians	Research and development technicians	
		Number	Percent of total			Number	Percent of total
All industries	593, 600	160, 600	27. 0	Machinery (except electrical)	72, 100	14, 400	19. 9
				Electrical equipment	79, 200	32, 700	41. 2
Food and kindred products	8, 100	1, 900	23. 0	Aircraft and parts	46, 800	29, 000	62. 1
Textile mill products and apparel	4, 700	1, 300	26. 4	Professional and scientific instruments	21, 300	8, 000	37. 4
Paper and allied products	6, 500	3, 000	45. 9	Other manufacturing industries	52, 500	17, 600	33. 6
Chemicals and allied products	39, 500	17, 800	45. 1	Construction	26, 800	1, 100	4. 0
Petroleum products and extraction	18, 100	6, 000	33. 0	Transportation and other public utilities	27, 000	600	2. 1
Stone, clay, and glass products	5, 000	1, 700	34. 7	Engineering and architectural services	63, 500	4, 900	7. 8
Primary metal industries	17, 900	3, 700	20. 3	Other nonmanufacturing industries	66, 800	8, 700	13. 0
Fabricated metal products and ordnance	37, 800	8, 400	22. 2				

NOTE.—Totals and percents have been calculated on the basis of unrounded figures and therefore may not correspond exactly with those indicated by the rounded figures shown.

TABLE A–20.—*Technicians primarily engaged in research and development, by size of company, January 1960*

Size of company	Total technicians	Research and development technicians		Size of company	Total technicians	Research and development technicians	
		Number	Percent of total			Number	Percent of total
All sizes	593, 600	160, 600	27. 0	500–999 employees	33, 700	6, 900	20. 3
				1,000–4,999 employees	72, 200	19, 300	26. 8
Under 100 employees	145, 400	10, 200	7. 0	5,000 or more employees	261, 300	107, 100	41. 0
100–499 employees	81, 000	17, 100	21. 1				

NOTE.—Totals and percents have been calculated on the basis of unrounded figures and therefore may not correspond exactly with those indicated by the rounded figures shown.

Appendix B

SCOPE AND METHOD

This appendix contains a brief discussion of background information necessary to the interpretation of the statistical findings, coverage and conduct of the survey, nature of the estimates, problems of definition and classification of data, and problems of comparability with previous surveys. A more technical discussion of the sampling scheme, estimating methods and problems, sampling variances, and related matters is contained in appendix C.

Coverage of the Survey

The sample of companies included in the survey was drawn primarily from the master list of those liable for OASI taxes, compiled by the Bureau of Old-Age and Survivors Insurance as of March 1956, the latest comprehensive listing available. The BOASI list was augmented by lists of Federal Reserve banks, and interstate railroads and related companies, which are not subject to OASI taxes. These combined lists included nearly 2,900,000 organizations with more than 41 million employees and represented the most comprehensive roster of companies available in the United States.

Certain categories of organizations were eliminated from the master list before the sample was selected, either because a separate survey of the given category was being sponsored by the National Science Foundation or because the number of scientific and technical personnel employed was believed to be negligible. The categories of organizations omitted were those classified according to the Standard Industrial Classification System [1] in the following major industry groups: 01—Farms; 80—Medical and other health services (except 807, medical and dental laboratories, which was included); 82—Educational services; 84—Museums, art galleries, and botanical and zoological gardens; 86—Nonprofit membership organizations; 88—Private households; 89—Miscellaneous services (except 891, engineering and architectural services, which was included); 90—Government; and 99—Nonclassifiable establishments.

Companies below a specified minimum size, determined separately for each major industry group, were also excluded from the listing (see table B–1). Because of the great numbers of firms

TABLE B–1.—*Minimum size-of-firm coverage of the survey*

Industry	*SIC code*	*Minimum size of company covered (number of employees)*
Food and kindred products	20	8
Textile mill products	22	8
Apparel	23	50
Paper and allied products	26	8
Chemicals and allied products	28	1
Products of petroleum and coal	29	1
Petroleum extraction	13	1
Stone, clay, and glass products	32	8
Primary metal industries	33	1
Fabricated metal products	34	1
Ordnance	19	1
Machinery (except electrical)	35	1
Electrical equipment	36	1
Motor vehicles and equipment	371	1
Aircraft and parts	372	1
Professional and scientific instruments	38	1
Lumber	24	50
Furniture	25	50
Rubber products	30	8
Tobacco manufacturers	21	8
Printing	27	8
Leather	31	8
Miscellaneous manufacturing	39	8
Transportation equipment (except motor vehicles and aircraft)	373, 374, 375	1
Construction	15, 16, 17	20
Telecommunications	48	8
Radio broadcasting and television	77	1
Railroads	40	100
All other transportation	41–47	8
Utilities and sanitary services	49	1
Engineering and architectural services	891	1
Mining	10, 11, 12, 14	8
Wholesale and retail trade and miscellaneous service industries	50–79 (except 77)	50
Agriculture, forestry, and fisheries	07, 08, 09	50
Medical and dental laboratories	807	1

[1] All industrial classification for this survey was in terms of the 1945 and 1949 Standard Industrial Classification Manuals. See Executive Office of the President, Bureau of the Budget, *Standard Industrial Classification Manual*, Vol. I (Parts 1 and 2, November and December 1945) and Vol. II (May 1949).

in the smallest size groups, very few of which employ any scientists or engineers, these minimum-size cutoffs were essential to the efficiency of the survey. All together, some 2.6 million companies employing nearly 12 million workers were excluded from the original lists of companies compiled, including those in the industries cited above and those below the specified minimum size. The fragmentary evidence available suggests that the firms thus excluded probably employed between 15,000 and 20,000 scientists and engineers, all together. This group comprised chiefly engineers in the construction industry, where a minimum size cutoff of 20 employees was judged to be necessary because of the difficulty of sampling the extremely large number of small construction contractors and because of the financial and other limitations on the survey.

Since the listing of companies from which the sample was drawn was compiled as of March 1956, the survey did not reach companies created after that date which were still in existence as separate entities in January 1960. It is estimated that the total number of scientists and engineers in firms created after March 1956 was not more than 15,000.

As a result of all the exclusions described above, a sampling universe of about 300,000 companies employing nearly 30 million workers remained. Before the survey sample was drawn, the universe listing was stratified by industry and size of company. All together, a sample of about 10,500 companies was selected at random. The sampling ratio was varied in relation to size of company and other factors to obtain maximum reliability at minimum cost. In every covered industry, companies with 1,000 or more employees were included in the sample. In other industry-size cells, the sampling ratios ranged from 1 in 2 to 1 in 100. In general, the larger the company and the greater the number of technical personnel used by the industry, the higher the sampling ratio.

Conduct of the Survey

The questionnaire for the current survey was substantially the same as that used in the 1959 survey of scientific and technical personnel in industry. Minor changes in definitions were adopted after consultation with the National Science Foundation and industry representatives. Copies of the questionnaire and of the covering and follow-up letters sent to companies are reproduced in appendix D.

The questionnaires were mailed to most companies in the sample on May 31, 1960. This date was chosen in order to coordinate the mailing of this survey of employment with the survey of research and development expenditures conducted by the Bureau of the Census. (See reference in covering letter.) Some of the largest companies were visited in person to discuss special reporting problems. At least two followups of all nonrespondents were made by mail or by telephone. About 9,500 companies, or approximately 90 percent of those in the sample, supplied usable information. This total count includes approximately 850 companies for which partial information was obtained in a final mail followup.[2] This took the form of an abbreviated questionnaire asking only for the total number of scientists and engineers and the total number of technicians employed.

Two different types of statistical findings were derived from the sample data. One type, designated as primary estimates, included the following items: Total employment, total scientists and engineers, total technicians, total number of companies employing scientists and engineers, and total number of companies employing technicians. The second type, designated as secondary estimates, were components of the primary estimates.

Primary estimates were obtained by computing for each cell a ratio of given primary item of estimate to the corresponding secondary item of estimate for companies reporting data for both items, e.g., 1960 scientists and engineers to 1959 scientists and engineers. The actual estimates were computed by multiplying the ratios by the related primary estimated item in January 1959 based on the estimates published in the 1959 report.[3] Industry and other totals were obtained by summing individual cell totals.

The secondary estimates were obtained by computing for each cell a ratio of the given component item to the corresponding primary item, using information only for those companies supplying data on both items. The secondary estimate was then derived by multiplying the ratio by the cell estimate of the related primary item.

Sampling errors were computed for estimates based on companies with employment of less than 1,000. In addition, "sampling" errors were cal-

[2] See appendix D.

[3] National Science Foundation, *Scientific and Technical Personnel in American Industry—Report on a 1959 Survey*—NSF 60–62 (U.S. Government Printing Office, Washington, 1960).

culated for industry-size classes composed of companies with 1,000 or more employees in which some of the companies were nonrespondents. Since imputations were based on the characteristics exhibited by the respondents, such "samling" errors could be meaningfully derived under the assumption that nonresponse will vary in its incidence from sample to sample. The accuracy of the estimates as indicated by the standard errors is discussed in appendix C. Additionally, as in all surveys, the data are subject to errors in reporting, in editing, and in tabulating. The number of such errors has been reduced as far as possible by checking procedures and through correspondence with a number of companies whose reports were internally inconsistent or appeared to involve misinterpretations.

Definitions

The definitions used in this survey, like other parts of the questionnaire, were essentially the same as those used in the 1959 survey. The aim was to describe clearly the desired information and also conform, insofar as possible, with customary personnel accounting practices. It was recognized, however, that wide differences in corporate organizations and in personnel records among industries and among companies in the same industry would make inevitable some variation in interpretation and application of the definitions. It was primarily for this reason that the questionnaire states: "Reasonable estimates will be satisfactory."

The definition of the term "technician" was especially subject to variation in interpretation. There is as yet no general agreement as to the meaning of this term, which covers positions with a variety of job titles differing among companies. Consequently the categories of personnel included in the figures reported on this item probably varied somewhat among respondents.

A definition of the desired reporting unit was also provided. This definition was based upon that used by the BOASI (Bureau of Old Age and Survivors Insurance) in the listing of companies from which the sample was drawn. Separate information was requested for each corporation or other legally separate company, covering all activities in the continental United States. Since it was known that some corporate families might find it difficult to supply the requested figures for each separately incorporated member of the family, it was stated on the questonnaire that data might, if necessary, be submitted on a consolidated basis. This alternative procedure was followed by 73 companies with 293 subsidiaries. The data on number of companies therefore represent separate legal entities, except for the relatively few (although important) cases of consolidated corporate-family reports.

In an effort to clarify the definitions of scientists and engineers, a sentence was added, in 1960, to each definitional category instructing the respondent not to include persons trained in science (or engineering) but currently employed in positions not requiring such training. Another minor change on the 1960 questionnaire related to the instructions for reporting on the item pertaining to the full-time equivalent number of scientists and engineers engaged in research and development. In an effort to relieve the reporting burden, respondents were instructed to omit entries in this item if the full-time equivalent figure was within 5 percent of the total number of scientists and engineers reported as primarily engaged in research and development.

Classification of Data

The industrial classifications of the companies in this survey were, in general, those assigned by the BOASI, which developed the list from which the sample was drawn. The industry categories used were those of the Standard Industrial Classification System. The industry of each establishment was determined on the basis of its principal activity or products; a company with more than one establishment was given the industry code of the establishment (or establishments) having the greatest number of employees.

The industry code assigned to a company by BOASI was changed in a relatively small number of cases of the two following types: (1) Where consolidated returns were received for a corporate family, all the companies in that family were shown in the industry with which the parent company was primarily associated; (2) where the industry classification of a few large companies by BOASI was inappropriate to the present survey, they were reclassified. Thus, several oil companies which were classified by BOASI in wholesale or retail trade were shifted to the petroleum products and extraction industry.

Since each report received in this survey covered an entire company (or family of companies) all personnel working for a given company had to be classified in the single industry with which this

company was primarily associated. The result was to include in the aircraft industry, for example, some engineers and scientists working in other fields such as electronics and, in the automobile industry, some working on aircraft engines and guided missiles. The industrial classification of the data thus has limitations not present to an equal extent in economic information obtained through surveys in which the reporting unit is an establishment.

The size categories in the survey were based on total company employment in all domestic activities as of March 1956. Since the sample was drawn from a listing of companies compiled as of March 1956 and stratified on the basis of company employment as of that date, use of these employment figures as the basis for classification of data in the report greatly simplified the tabulations. In addition, analyses of data from earlier surveys support the belief that patterns of scientific and technical employment by March 1956 employment size would not be significantly different from those by January 1960 size.

Comparability With Earlier Surveys

Because of the importance of historical information on employment of scientists and engineers, a detailed comparative analysis has been made of the results of this survey and those of the three earlier ones conducted by the Bureau of Labor Statistics for the National Science Foundation.[4] The last two surveys—1959 and 1960—are directly comparable insofar as it is possible to control a sample survey.[5] The same sample of companies was used, virtually identical questionnaires and definitions were employed, and the response rates to both surveys were excellent (90 percent). However, the responding companies—particularly those in small-size cells—were not necessarily the same for both years. Furthermore, reports from the same companies often indicated a change from the previous year in the interpretation of definitions; such changes particularly affected occupational statistics. The variations are believed to have little effect on the comparability of the data, except for items where very small numbers are involved. (See appendix C for a discussion of sampling and response errors.)

The surveys of scientific and technical personnel conducted prior to 1959 are not completely comparable for a number of technical reasons which affect the overall estimates of scientific and technical employment and, to a much greater extent, the estimates for different industries and sizes of companies. Whereas the 1959 and 1960 surveys were devoted exclusively to collection of information on scientific and technical personnel, the 1953–54 and 1956 surveys emphasized questions relating to R&D costs. Furthermore, companies without R&D were requested to supply only a few overall figures on their scientific and technical staffs.

Major changes were also made in the questionnaire design, beginning with the 1959 survey. A fairly detailed two-way breakdown of scientific and technical personnel by occupational group and function was introduced. In addition, a new question calling for the breakdown of technician employment into several occupational groups was added. Moreover, an instruction to include trainees for technician positions was dropped from the 1959 questionnaire. Although these and other changes are believed to have contributed to greater accuracy in the estimates, they also affected the comparability of the surveys.

(For a more complete discussion of the differences between the 1959 and earlier surveys, see publication cited in footnote 3 on p. 38.)

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[4] National Science Foundation, *Scientific and Technical Personnel in American Industry—Report on a 1959 Survey* (1960); *Science and Engineering in American Industry—Report on a 1956 Survey* (1959); and *Science and Engineering in American Industry—Final Report on a 1953–1954 Survey* (1956); U.S. Government Printing Office, Washington.

[5] Data for 1958 were collected on the 1959 questionnaire and are, therefore, also comparable with 1960 data.

Appendix C

TECHNICAL NOTES

General Sampling Scheme

The overall design was that of a stratified random sample of companies drawn from individual industry size classes. The universe was that of companies subject to Bureau of Old Age and Survivors Insurance coverage in the first calendar quarter of 1956. The sample was the same as that used in the 1959 Survey of Scientific and Technical Personnel.

Industry classification of companies was based on information available to BOASI and to the Bureau of the Census and was used in the preparation of the 1956 County Business Patterns. Size classification was determined from mid-March 1956 employment.

The survey was planned primarily as a mail survey with followups by mail and by telephone. Personal contact was made, mainly with large companies, to explain the survey and assure response. Experience with earlier surveys had indicated that the response to the mail questionnaire would be very high and that bias, if any, among the nonrespondents would be slight.

Sample numbers were allocated among the various strata in accordance with the principle of optimum allocation, taking into account the expected response rates by industry and by size. The overall sample size was determined so that the 95-percent tolerance band (two relative standard errors) for the estimate of the total number of scientists and engineers for all industries combined would be about 3 percent. Cell variances of the numbers of scientists and engineers and covariances of these numbers with total employment derived from the 1954 Survey of Industrial Research and Development were used in the allocation procedure. Reciprocals of the initially determined sampling ratios were rounded to the nearest one of the following values: 1, 2, 5, 10, 20, 50, and 100. Sampling ratios varied from certainty for all companies with 1,000 or more employees to a low of 1 in 100 for small companies in industries having relatively few scientists and engineers. All selections were made at random within the designated strata. The selection of the sample, accomplished mechanically by BOASI, yielded about 10,500 cases with March 1956 employment of approximately 16 million workers, or about 39 percent of all private, nonagricultural employment covered by OASI.

Estimating Methods and Problems

Estimating Methods. Two kinds of estimates were derived from the survey—primary and secondary estimates. These are described below.

The symbols used in the estimating equations are as follows:

N —total number of companies.

T_{59}—estimated primary item for January 1959, i.e., the number published in the 1959 report, or a component of a published 1959 total.

R —ratio of sample total of the primary item in January 1960 to the sample total of the primary item in January 1959, based on matched reports in the 1960 survey.

t_{60_i}—primary 1960 item of estimate reported by the i–th sample company in January, 1960.

t_{59_i}—secondary 1959 item of estimate reported by the i–th sample company in January, 1960. (This item was a primary item of estimate in the 1959 STP Survey.)

c_i —secondary item of estimate for the i–th sample company reporting it.

n —number of companies in the designed sample.

n_c —number of companies in the sample responding on the c–th secondary item.

n_r —number of companies in the sample responding for the match of a primary item (answering both t_{60_i} and t_{59_i} items).

Since all primary and secondary estimates, and their variances, are calculated separately for each

industry size stratum, no notation is introduced to represent industry or size in the formulas.

A primary estimate, such as total scientists and engineers, January 1960, is specified as follows:

$$T_{60}=T_{59}R$$

$$\text{where } R=\frac{T'_{60}}{T'_{59}}=\frac{\sum_{i}^{n_r} t_{60_i}}{\sum_{i}^{n_r} t_{59_i}}$$

The summation in the numerator and denominator is for those sample companies reporting both of the specific t_{60_i} and t_{59_i} items on the schedule. T'_{60} and T'_{59} are alternate expressions for the sample summations.

A secondary estimate is either a component of or closely related to a primary item. It is estimated as follows:

$$c'=T_{60}\frac{\sum_{i}^{n_s} c_i}{\sum_{i}^{n_s} t_{60_i}}$$

where the summation in the numerator and denominator is for those sample companies reporting both of the t_{60_i} and c_i items on the schedule.

Estimates of primary or secondary item totals by industry, or for all industries combined, are obtained by summation of the relevant stratum estimates.

Business Deaths, Mergers, and Consolidations. Many special adjustments were made in company returns because of changes in company structure. Companies whose schedules were returned with such notations as "Out of business" or "Moved, no forwarding address," were checked in BOASI records as to the last time period for which tax returns had been filed. In a few cases, new names and addresses were found for companies still in business, and schedules were sent to them. Other companies which were definitely determined to be out of business were classified as business deaths as of January 1960.

Special editing procedures were devised for business mergers and for companies sold to other companies. Such companies which were determined to have lost their separate legal identities through sale or merger by January 1960 were classified as out of business cases.

Consolidations presented a problem arising from the survey itself, rather than from changes in business organization. Since the sample of companies was drawn from the BOASI master file of companies with separate employer identification numbers, it was intended that reporting units in the survey have the same identities. However, some corporate families were not able to prepare separate reports for each company in their organization, but submitted consolidated returns covering two or more companies. Companies returning such consolidated schedules were asked to list the names of all subsidiaries or affiliates covered by the return. To maintain an unbiased estimation procedure, benchmark employment (March 1956) totals were adjusted for all cells in which there were companies whose data were included on consolidated returns. On the basis of information furnished with or on the consolidated return, a parent company was designated for each corporate family. Data on the consolidated return were included in the industry size class of the parent company. Benchmark employment for every other company in the corporate family (whether or not it was in the sample) was removed from its corresponding cell with the weight (reciprocal of the sampling ratio) of the cell of the parent company, and added to the benchmark employment of the parent cell with the same weight. In other words, the probability of selection of each company was replaced by the probability of selecting the parent. For consolidatees in the original sample, individual company items were edited to zero.

Sampling Variances. The sampling accuracy of a large proportion of the primary and secondary estimates was determined for use in analysis and publication of the estimates. Attention is focused here on the measurement of sampling errors. It should be noted however, that the conventional variance formulas for sample derived estimates also measure a certain amount of nonsampling error, such as errors of response in the data returned on the schedules. Some additional discussion of these types of errors is given below.

Standard errors of level and change for selected estimates are presented in appendix tables C–3 to C–9 inclusive. For about two of every three possible samples of the same size, the estimate derived from the sample is within one standard error of that obtained by a complete count; e.g., for the chemicals and allied products industry, the standard error for the level of estimate of scientists and engineers—90,700—was 2 percent. For 19 out of 20 possible samples, the tolerance

is within twice the limit shown in the tables, e.g., 4 percent of the total number of scientists and engineers in the chemical and allied products industry. In addition, this industry showed an increase of 9 percent in the level of scientists and engineers from 1959 to 1960. For about 2 out of every 3 samples, this percentage increase will be within 2 percentage points of that obtained from a complete count. For 19 out of 20 possible samples, the error is 4 percentage points.

In general, it may be expected that the actual error, due to sampling variability, for a particular estimate is less than the error shown in the table. Standard errors for primary and secondary estimates were calculated on the basis of reported data only, and on the sample number of companies reporting for the specified item. Because of this, the tables record standard errors other than zero for many of the industry size classes with more than 1,000 employees, although these cells had been sampled with certainty.

Variances of Primary and Secondary Items. The symbols used earlier in this appendix are also used in the variance formulas given below. Additional symbols are defined as necessary.

The variance of level of a primary amount, such as the number of scientists and engineers, for a given industry size stratum is approximately:

$$\sigma^2_{T_{60}}=\left[\frac{N-n_r}{n_r(N-1)}\right](T_{60})^2(V^2_{t_{60}}+V^2_b-2V_{t_{60}b})$$

where $V^2_{t_{60}}$ and V^2_b are rel-variances, and $V_{t_{60}b}$ is the rel-covariance, and are defined as follows:

$$V^2_{t_{60}}=\frac{\sigma^2_{t_{60}}}{\bar{t}^2_{60}}=\frac{\frac{1}{N}\sum_i^N t^2_{60_i}-\bar{t}^2_{60}}{\bar{t}^2_{60}},\ \text{with}\ \bar{t}_{60}=\frac{1}{N}\sum_i^N t_{60_i}$$

V^2_b is expressed in a similar fashion with b_i equal to the March 1956 BOASI employment for the i–th company.

The rel-covariance is

$$V_{t_{60}b}=\frac{\sigma_{t_{60}b}}{\bar{t}_{60}\bar{b}}=\frac{\frac{1}{N}\sum_i^N t_{60_i}b_i-\bar{t}_{60}\bar{b}}{\bar{t}_{60}\bar{b}}$$

The rel-variances and rel-covariances defined for the stratum universe, were estimated from the sample of companies reporting for this item. Two formulas were used to approximate the variance of the change in the amount primary item from 1959 to 1960. The first formula approximated the variance of change for an industry-size stratum. The second variance formula dealt with corresponding estimates of these variances at various levels of aggregation, such as individual industry levels and the all-industry level.

The variance of change for the amount primary item for the i–th industry, j–th size class is approximated by the following formula:

$$\sigma^2_{R_{ij}}=R^2(V^2_{T'_{60}}+V^2_{T'_{59}}-2V_{T'_{60}T'_{59}})$$

where $V^2_{T'_{60}}$ and $V^2_{T'_{59}}$ are rel-variances and $V_{T'_{60}T'_{59}}$ is the rel-covariance, and are estimated as follows:

$$V^2_{T'_{60}}=\frac{\sigma^2_{T'_{60}}}{T'^2_{60}}=\frac{n_r(N-n_r)}{(n_r-1)(N-1)}\frac{\left[\sum_i^{n_r} t^2_{60_i}-n_r(\bar{t}_{60})^2\right]}{T'^2_{60}}$$

with $\bar{t}_{60}=\dfrac{\sum_i^{n_r} t_{60_i}}{n_r}$

$V^2_{T'_{59}}$ is expressed in a similar fashion. The rel-covariance is estimated by

$$V_{T'_{60}T'_{59}}=\frac{\sigma_{T'_{59}T'_{60}}}{T'_{60}T'_{59}}=\frac{n_r(N-n_r)}{(N-1)(n_r-1)}\times\left[\sum_i^{n_r}\frac{t_{60_i}t_{59_i}-n_r\bar{t}_{60}\bar{t}_{59}}{T'_{60}T'_{59}}\right]$$

The variance of the ratio of change at various levels of aggregation is based on the following formula for estimating the ratio of change for the amount primary item (using the i–th industry total by way of illustration):

$$R_i=\frac{T_{60_i}}{T_{59_i}}=\sum_{j=1}T_{60_{ij}}\Big/\sum_{j=1}T_{59_{ij}}$$

The indicated summation (j) is over all size classes in the i–th industry.

The rel-variance of R_i is approximately

$$V^2_{R_i}=\sum_{j=1}w^2_{ij}V^2_{R_{ij}}$$

where w_{ij} is the proportion of the estimated primary amount item in industry i which is in size class j, and the $V^2_{R_{ij}}$ have already been calculated for the individual size classes.

In a similar way, the rel-variance of the ratio of change is developed for groups of industries combined.

The variance of a secondary item, such as the number of scientists and engineers in research and

development, for a given industry size stratum is approximated by:

$$\sigma^2_{C'} = \frac{N-n_c}{n_c(N-1)} (C')^2(V_c^2+V_b^2-2V_{cb})$$

with the rel-variances and rel-covariances defined in a similar way to the corresponding terms in the variance for primary estimates.

The relative standard errors, presented in tables C–3 to C–10 inclusive, are defined as follows for a primary estimate:

$$e_T = \frac{\sigma_{T'}}{T'}.$$

Analogous expressions hold for the other estimates.

Tables C–1 and C–2 present representative response rates for particular primary estimates by industry and size class. The level of the response

TABLE C–1.—*Response rates for scientists and engineers, by industry and size of company, January 1960*

[Percent]

Industry	All companies	Companies with total employment of—				
		Under 100 [1]	100–499	500–999	1,000–4,999	5,000 or more
All industries	88	86	88	89	89	91
Food and kindred products	90	89	88	95	95	79
Textile mill products and apparel	81	70	85	92	83	78
Paper and allied products	90	100	93	90	86	86
Chemicals and allied products	89	90	85	84	86	100
Petroleum products and extraction	89	86	89	83	100	96
Stone, clay, and glass products	90	92	93	91	85	86
Primary metal industries	90	91	82	83	92	91
Fabricated metal products and ordnance	86	85	92	89	79	92
Machinery (except electrical)	89	90	90	90	83	93
Electrical equipment	85	86	88	78	83	85
Motor vehicles and equipment	88	93	86	90	80	94
Aircraft and parts	94	93	87	100	95	96
Professional and scientific instruments	88	88	85	93	90	100
Other manufacturing industries	90	86	91	93	91	87
Construction	81	82	80	78	88	100
Transportation and other public utilities	89	85	91	93	92	97
Other nonmanufacturing industries	89	86	88	91	93	92

[1] See table B–1, appendix B, for sample cutoff for industries in this size class.

TABLE C–2.—*Response rates for technicians, by industry and size of company, January 1960*

[Percent]

Industry	All companies	Companies with total employment of—				
		Under 100 [1]	100–499	500–999	1,000–4,999	5,000 or more
All industries	86	85	86	87	88	89
Food and kindred products	89	89	87	95	92	79
Textile mill products and apparel	79	69	81	92	80	78
Paper and allied products	90	100	93	90	86	86
Chemicals and allied products	85	86	79	83	85	97
Petroleum products and extraction	88	86	89	78	100	92
Stone, clay, and glass products	88	91	93	91	83	79
Primary metal industries	89	89	82	83	90	91
Fabricated metal products and ordnance	84	84	92	86	77	85
Machinery (except electrical)	87	88	88	89	82	91
Electrical equipment	84	84	87	78	84	85
Motor vehicles and equipment	88	93	86	90	80	94
Aircraft and parts	90	89	87	100	89	93
Professional and scientific instruments	86	85	82	93	90	100
Other manufacturing industries	89	86	90	92	86	87
Construction	79	79	78	75	83	100
Transportation and other public utilities	87	84	89	89	91	90
Other nonmanufacturing industries	87	84	86	89	91	88

[1] See table B–1, appendix B, for sample cutoff for industries in this size class.

TABLE C-3.—*Relative standard errors for scientists and engineers, by industry and size of company, January 1960*

Industry	All companies	Companies with total employment of—				
		Under 100 [1]	100–499	500–999	1,000–4,999	5,000 or more
All industries	2	7	7	8	2	1
Food and kindred products	8	43	28	(2)	5	7
Textile mill products and apparel	17	(2)	30	27	7	20
Paper and allied products	7	(2)	34	46	6	10
Chemicals and allied products	2	11	14	6	7	0
Petroleum products and extraction	5	26	28	22	6	5
Stone, clay, and glass products	8	36	37	33	6	9
Primary metal industries	3	34	26	27	4	3
Fabricated metal products and ordnance	13	42	24	24	10	4
Machinery (except electrical)	3	12	8	8	4	2
Electrical equipment	5	11	14	22	8	6
Motor vehicles and equipment	1	(2)	21	20	15	1
Aircraft and parts	1	44	21	26	13	1
Professional and scientific instruments	8	39	18	14	6	0
Other manufacturing industries	7	25	31	28	6	2
Construction	12	29	17	18	7	0
Transportation and other public utilities	5	42	22	26	2	2
Other nonmanufacturing industries	6	8	20	31	7	2

[1] See table B-1, appendix B for sample cutoff for industries in this size class. [2] 50 percent or more.

TABLE C-4.—*Relative standard errors for technicians, by industry and size of company, January 1960*

Industry	All companies	Companies with total employment of—				
		Under 100 [1]	100–499	500–999	1,000–4,999	5,000 or more
All industries	3	11	10	7	2	2
Food and kindred products	14	44	30	37	7	9
Textile mill products and apparel	22	(2)	45	44	9	18
Paper and allied products	15	(2)	(2)	(2)	8	11
Chemicals and allied products	4	20	18	7	8	5
Petroleum products and extraction	8	(2)	(2)	34	13	3
Stone, clay, and glass products	11	47	38	40	8	14
Primary metal industries	3	(2)	24	36	5	2
Fabricated metal products and ordnance	16	40	29	36	10	7
Machinery (except electrical)	4	16	10	10	4	4
Electrical equipment	5	16	18	18	13	7
Motor vehicles and equipment	1	42	24	22	16	1
Aircraft and parts	1	(2)	34	29	13	0
Professional and scientific instruments	13	38	15	10	9	1
Other manufacturing industries	21	(2)	28	29	5	2
Construction	26	(2)	28	38	10	15
Transportation and other public utilities	18	(2)	22	24	4	6
Other nonmanufacturing industries	10	14	27	9	13	6

[1] See table B-1, appendix B for sample cutoff for industries in this size class. [2] 50 percent or more.

rate for a particular estimate affects the relative errors to some extent, since the estimating formulas for the latter are based on the number of companies reporting the particular item.

In general, the relative errors are larger for the smaller size classes. As a rule, they are larger for smaller aggregates. In addition, it is likely that the net effect of response errors is larger for the smaller aggregates. Hence, smaller and more detailed figures should be used with caution.

Nonsampling Error. The results of this survey (as well as of others conducted in the past) are subject to a number of limitations, some of which have been discussed in appendix B. Among these limitations are nonsampling errors, of all kinds, already referred to briefly. These errors fall in

TABLE C–5.—*Relative standard errors for scientists and engineers and R&D scientists and engineers, by occupation, January 1960*

[Percent]

Occupation	Standard error, scientists and engineers	Standard error, R&D scientists and engineers
All scientists and engineers	1	2
Engineers	2	2
Chemists	3	3
Physicists	4	4
Metallurgists	6	10
Geologists and geophysicists	7	6
Mathematicians	5	3
Medical scientists	8	13
Agricultural scientists	9	8
Biological scientists	7	6
Other scientists	9	8

TABLE C–6.—*Relative standard errors for scientists and engineers, by primary function, January 1960*

[Percent]

Primary function	Standard error
All scientists and engineers	1
R&D scientists and engineers	2
Management and administration of R&D	3
Management and administration of all other activities	3
Exploration	7
Production and operations	2
All other activities	4

TABLE C–7.—*Relative standard errors for technicians, by occupation, January 1960*

[Percent]

Occupation	Standard error
All technicians	3
Draftsmen	3
Engineering and physical science technicians	3
Medical, agricultural, and biological technicians	8
All other technicians	6

two categories: Systematic errors and random errors. Systematic errors will tend, on the average, to raise or lower certain of the estimates from the survey by comparison with estimates derived from another source. There is some evidence of the presence of systematic effects of this kind in the present survey, for example, in the estimated number of small companies with scientists and engineers.

Random errors may or may not be correlated with the estimates themselves. To the extent that they do not have a marked negative correlation with the survey data (excluding nonsampling errors), they probably help to raise the calculated

TABLE C–8.—*Standard errors for percent change of scientists and engineers from January 1959 to January 1960, by industry*

Industry	Percent change	Standard error
All industries	6.4	2
Food and kindred products	−2.7	11
Textile mill products and apparel	8.1	5
Paper and allied products	7.9	1
Chemicals and allied products	9.0	1
Petroleum products and extraction	1.4	4
Stone, clay, and glass products	10.3	7
Primary metal industries	5.7	1
Fabricated metal products and ordnance	9.8	2
Machinery (except electrical)	6.0	1
Electrical equipment	9.4	1
Aircraft and parts	7.0	1
Professional and scientific instruments	11.3	1
Other manufacturing industries	7.8	1
Construction	3.2	4
Transportation and other public utilities	3.8	5
Engineering and architectural services	1.3	1
Other nonmanufacturing industries	5.7	8

TABLE C–9.—*Standard errors for percent change of technicians from January 1959 to January 1960, by industry*

Industry	Percent change	Standard error
All industries	8.1	5
Food and kindred products	53.9	26
Textile mill products and apparel	22.1	14
Paper and allied products	5.4	2
Chemicals and allied products	14.9	3
Petroleum products and extraction	−.3	6
Stone, clay, and glass products	9.8	6
Primary metal industries	6.4	2
Fabricated metal products and ordnance	10.6	5
Machinery (except electrical)	10.3	2
Electrical equipment	17.5	3
Aircraft and parts	−10.9	3
Professional and scientific instruments	9.0	8
Other manufacturing industries	.5	3
Construction	26.5	12
Transportation and other public utilities	7.7	21
Engineering and architectural services	1.9	18
Other nonmanufacturing industries	10.8	11

TABLE C–10.—*Relative errors based on total sampling and nonsampling variance and usual measure of sampling variance for scientists and engineers and for technicians, selected industries, January 1960*

[Percent]

Industry	Relative errors for scientists and engineers based on—		Relative errors for technicians based on—	
	Total sampling and nonsampling variance	Usual measure of sampling variance	Total sampling and nonsampling variance	Usual measure of sampling variance
All industries	2	2	3	3
Food and kindred products	9	8	15	14
Chemicals and allied products	2	2	5	4
Professional and scientific instruments	8	8	14	13
Aircraft and parts	3	1	5	1
Construction	14	12	31	26

standard errors presented in the tables. Ordinarily it has not been possible to determine their magnitude separately. In the present survey, however, information was available to permit estimation of a limited amount of nonsampling error. Since this survey asked for 1959 data again so as to provide a link with the previous year's survey estimates (see NSF 60–62), two separately reported 1959 figures were available for the great majority of companies in the sample for the number of scientists and engineers and the number of technicians. With the use of a mathematical model which assumes the presence of nonsampling error in all responses, estimates were developed of this error, and subsequently of the total error, combining both the sampling and nonsampling components. Comparisons between the relative errors based on the total and the usual variance formulas for scientists and engineers and technicians are presented in table C–10 for selected industries.

The formulas used to estimate the nonsampling variance are presented below. First, a few remarks are in order about the kind of nonsampling errors included and excluded. The error of bias (such as a consistent over or understatement of a figure by a respondent on both surveys) cannot be measured by the available data. Several other kinds of possible nonsampling error are beyond the scope of the present inquiry, such as errors arising from improper size and industry classification of the companies in the universe from which the sample was selected, errors in the benchmark (1956 OASI) employment used in the estimating formulas, and variation in response related to the use of alternative types of questionnaires. The present measures of nonsampling error do include the variation in response to the same item at different times from either the same individual, or from different individuals in the company. One of the estimates of nonsampling error also includes errors arising from estimating, imputation and processing sources. Given the estimates of total error presented here, it is possible to say, for example, that in the food industry the estimated number of scientists and engineers (9,900) will be within one total standard error (9 percent) of the average number reported—theoretically on many repetitions of a complete count—for two out of three possible repetitions of this sample survey, using the same questionnaire and definitions.

Several observations should be made here in connection with these estimates: (1) The usual sampling standard errors already include a partial allowance for nonsampling error; (2) full allowance for the nonsampling errors adds to the sampling errors as usually computed; (3) nonsampling error will exist even in those industry size classes with a 100 percent sample and complete response.

The nonsampling error model used here is the following:

$$t_{ij}=y_i+e_{ij}^*$$

where t_{ij} is the figure reported by the i–th company on the j–th survey, y_i is the "true" value

*The formulas for nonsampling error variance presented here are related to inflation estimates of population aggregates, but are good approximations for the present purpose.

for the i–th company, and e_{ij} is the nonsampling error in t_{ij}. Let t_{i1} and t_{i2} represent two observations of the same quantity for the i–th company. Two measures of the difference in these observations, which are functions of the nonsampling error, are:

$$D_1=\sum_{i=1}^{n'}(t_{i1}-t_{i2})^2$$

where n′ is the number of companies in the sample reporting both t_{i1} and t_{i2}, and $D_2=(T_1'-T_2')^2$ where T_1' and T_2' are the two sample based estimates of the population total of this item. Estimate D_2 incorporates a measure of some of the imputation, estimation and processing error, while estimate D_1 does not. Let:

A represent the sampling error or level of variance of T_1' (or T_2') as customarily computed;

B represent the estimate of sampling error variance, if no nonsampling error (as measured here) were present;

C represent the total variance, including both sampling and nonsampling error:

E represent the nonsampling error variance.

The various error variances are related as follows:

$$C=B+E$$

$$C=A+\frac{n''(N-1)}{2N(n''-1)}D_2-\frac{N(N-n'')}{2n'(n''-1)}D_1$$

$$E=\frac{D_2}{2}$$

where n' has already been defined, n is the designed sample number and n'' is the number of sample companies reporting item t.

Appendix D

QUESTIONNAIRES AND COVERING LETTERS

B.L.S. No. 3074

Budget Bureau No. 44-S006.
Approval expires December 31, 1960.

A Survey of

SCIENTIFIC AND TECHNICAL PERSONNEL: 1960

Conducted for the NATIONAL SCIENCE FOUNDATION by the U.S. DEPARTMENT OF LABOR Bureau of Labor Statistics

Your reply will be held in STRICT CONFIDENCE

The purpose of this survey is to provide up-to-date information on the Nation's scientists, engineers, and technicians to aid in developing programs and policies designed to strengthen the country's scientific manpower resources and research effort. All information supplied on this form will be seen only by sworn employees of the Bureau of Labor Statistics and the National Science Foundation. Only statistical summaries that will preserve confidentiality of individual company reports will be released.

GENERAL INSTRUCTIONS

It is important that we obtain a reply from your company even if it does not employ scientists, engineers, or technicians. In that case, please answer only the questions on this page.

Please supply as much information as possible even if data are not available on all questions. Reasonable estimates will be satisfactory. Write "None" where appropriate, or "Not available" if such is the case, rather than leave a blank space. All employment figures should apply, if possible, to pay period ending nearest the 15th of indicated month.

Coverage of questionnaire. Replies are needed from each company—whether parent, subsidiary, affiliate, or independent—to which a questionnaire is sent (see definition of "reporting company" on page 3). Please supply the information for your company only, excluding data on separately incorporated parents, subsidiaries, or affiliates. However, if it would not be feasible to supply separate figures for each company in your corporate family, please send in a consolidated return and list on page 5 all subsidiaries and affiliates covered by the data.

If extra copies of the questionnaire would be helpful, they may be obtained on request. Mail completed questionnaire to:

COMMISSIONER OF LABOR STATISTICS,
U.S. DEPARTMENT OF LABOR,
Washington 25, D.C.

TERMS IN HEAVY CAPITALS ARE DEFINED ON PAGE 3

1. Please give total number of persons on the payroll of the REPORTING COMPANY in all activities in the United States in:

January 1960 ..... **January 1959** .....
(This figure is needed for technical reasons in making comparisons with previous surveys.)

2. Were any of the persons reported under item 1 above for January 1960 working as:

A. SCIENTISTS or ENGINEERS? Yes ☐ No ☐ **B. TECHNICIANS? Yes ☐ No ☐**

PLEASE COMPLETE FORM IF ANSWER TO EITHER 2A OR 2B IS YES.
COMPLETE ONLY THIS PAGE IF ANSWERS TO BOTH ARE NO.

Change address if incorrect

Is the REPORTING COMPANY a subsidiary of any other company?

Yes ☐ No ☐

If yes, give name of parent company .....

.....

Person to be addressed if questions arise concerning this report:

.....

Telephone No.: .....

To receive notice of publication of the report on the survey findings, please check: ☐

TERMS PRINTED IN HEAVY CAPITALS ARE DEFINED. PLEASE READ DEFINITIONS CAREFULLY.

3. Please give total number of persons working as SCIENTISTS or ENGINEERS in all parts of the REPORTING COMPANY in:

A. January 1960 ..... B. January 1959 .....

4. Please classify the SCIENTISTS and ENGINEERS reported in item 3 by the occupations and functions in which they are primarily employed.

Instruction 1. Personnel in borderline specializations such as biochemistry should be classified in the listed occupations with which their work is most closely identified. (Occupations are defined on pages 3 and 4.)

Instruction 2. Persons performing more than one function should be classified in the function occupying the greatest proportion of their time. (Functions are defined on page 4.)

OCCUPATIONS	JANUARY 1960							JANUARY 1959*
		PRIMARY FUNCTION						
	TOTAL EMPLOYED IN ALL FUNCTIONS	RESEARCH-DEVELOPMENT	MANAGEMENT AND ADMINISTRATION OF		EXPLORATION	PRODUCTION AND OPERATIONS	ALL OTHER ACTIVITIES	TOTAL EMPLOYED IN ALL FUNCTIONS
			RESEARCH-DEVELOPMENT	Other activities				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Total SCIENTISTS and ENGINEERS								
A. ENGINEERS (all types) . . .								
B. Chemists								
C. Physicists								
D. Metallurgists . . .								
E. Geologists and geophysicists . . .								
F. MATHEMATICIANS								
G. MEDICAL SCIENTISTS (Exclude practitioners) . . .								
H. AGRICULTURAL SCIENTISTS . . .								
I. BIOLOGICAL SCIENTISTS . .								
J. Other (please specify):								

*PLEASE NOTE: January 1959 data (items 1, 3, 4, and 7) are needed to insure that valid comparisons can be made between the results of this survey and those of the previous survey (BLS Form 2625). The data for January 1960 and the data for January 1959 should each apply to the entire REPORTING COMPANY as constituted on the respective dates and should be comparable with respect to the personnel categories covered. If a revision of the 1959 data reported last year on BLS Form 2625 is needed for comparability with your January 1960 data, please supply corrected 1959 figures and explain the revisions under REMARKS on page 6.

5. Approximately how many of the SCIENTISTS and ENGINEERS performing or administering RESEARCH-DEVELOPMENT (sum of columns 2 and 3, item 4) were working primarily on BASIC RESEARCH? . . . .

TERMS PRINTED IN HEAVY CAPITALS ARE DEFINED. PLEASE READ DEFINITIONS CAREFULLY.

6. Of the total SCIENTISTS and ENGINEERS reported in January 1960 (item 3A), please give number employed full time in the performance of RESEARCH-DEVELOPMENT and in the MANAGEMENT AND ADMINISTRATION of RESEARCH-DEVELOPMENT plus FULL-TIME EQUIVALENT of those working part time in these activities. (Include all time spent in these activities regardless of primary function category in which individuals were placed in item 4.)

NOTE: If the total full-time equivalent of SCIENTISTS and ENGINEERS engaged in RESEARCH-DEVELOPMENT (item 6C) is believed to be about the same, i.e., within 5 percent, as the sum of columns 2 and 3 of item 4, do not answer items 6A and 6B. In such case, enter the sum of columns 2 and 3 of item 4 in item 6C.

A. Number employed full time in the performance or administration of RESEARCH-DEVELOPMENT . . ..

B. FULL-TIME EQUIVALENT of those working part time in the performance or administration of RESEARCH-DEVELOPMENT . . . .

C. Total (need not agree with the sum of columns 2 and 3 of item 4) . . . .

7. Of the total number of persons on the payrolls of the REPORTING COMPANY, how many were TECHNICIANS?

	January 1960	*January 1959*
Total	=====	=====
A. Draftsman	.....	XXXXXXXXXXXXX
B. Engineering and physical-science technicians	.....	XXXXXXXXXXXXX
C. Medical, agricultural, and biological technicians	.....	XXXXXXXXXXXXX
D. All others	.....	XXXXXXXXXXXXX

8. Of the TECHNICIANS reported for January 1960 in item 7, how many were primarily in RESEARCH-DEVELOPMENT? . . . .

DEFINITIONS

(In order of first use of term)

REPORTING COMPANY.—A corporation, partnership, or proprietorship and all its nonincorporated divisions and departments in the United States. Data on all items in this questionnaire should apply to entire company as thus defined. Companies with separately incorporated subsidiaries or affiliates, please see instructions on front page.

SCIENTISTS.—All persons engaged in scientific work which requires a knowledge of or training in physical, life, engineering, or mathematical sciences equivalent at least to that acquired through completion of a 4-year college course with a major in these fields. Include all persons in research-development, production, management, technical service, technical sales, and other positions who have the equivalent of college training in science and are required to use this training in their work. Do not include persons trained in science but currently employed in positions not requiring such training. Exclude psychologists and social scientists.

ENGINEERS.—All persons engaged in chemical, civil, electrical, mechanical, metallurgical and other types of engineering work at a level which requires a knowledge of or training in engineering, physical, life, or mathematical sciences equivalent at least to that acquired through completion of a 4-year college course with a major in these fields. Include all persons in research-development, production, management, technical service, technical sales, and other positions who have the equivalent of college training in engineering and are required to use this training in their work. Do not include persons trained in engineering who are currently employed in jobs not requiring such training.

TECHNICIANS.—All persons engaged in work requiring knowledge of physical, life, engineering, and mathematical sciences comparable to knowledge acquired through technical institute, junior college, or other formal post-high school training, or through equivalent on-the-job training or experience. Some typical job titles are: Laboratory assistants, physical science aids, and electronic technicians. All employees in positions requiring the indicated level of knowledge and training should be included regardless of job title and company department in which employed. Exclude craftsmen such as machinists and electricians.

DEFINITIONS

MATHEMATICIANS.—Scientists primarily engaged in development or utilization of advanced mathematical techniques, including actuaries and mathematical analysts. Include statisticians and programmers for computers only if they specialize in mathematical techniques. Exclude accountants.

MEDICAL SCIENTISTS.—Physicians, dentists, public health specialists, pharmacists, and members of other scientific professions concerned with the understanding of human diseases and improvement of human health, who are engaged in clinical investigation and other research, production, technical writing, and related activities. Exclude those primarily engaged in providing care to patients, dispensing drugs or services, diagnosis, etc., from all figures on scientists and engineers. Also exclude persons employed as pathologists, microbiologists, pharmacologists, etc., from the figures on medical scientists but include them in the figures on biological scientists.

AGRICULTURAL SCIENTISTS.—Scientists primarily engaged in understanding and improving agricultural productivity, such as those working in agronomy, animal husbandry, forestry, horticulture, range management, soil culture, and veterinary science. Exclude veterinarians primarily engaged in providing care to animals.

BIOLOGICAL SCIENTISTS.—All scientists, other than agricultural and medical scientists, who work in sciences which deal with life processes, including pathologists, microbiologists, pharmacologists, bacteriologists, toxicologists, botanists, zoologists, etc.

RESEARCH-DEVELOPMENT.—Include basic and applied research in the natural sciences (including medicine) and engineering, and design and development of prototypes and processes. Does not include quality control, routine product testing, market research, sales promotion, sales service, or other nontechnical activities or technical services. If the primary objective is to make further improvements on the product or process, then the work is research-development. If, on the other hand, the product or process is substantially "set," and the primary objective is to develop markets, do preproduction planning, or get the production process going smoothly, then the work is no longer research-development. Include all supervisors who spend more time on actual research-development work than on administration of research-development.

MANAGEMENT AND ADMINISTRATION.—Administrative and management work requiring a scientific and engineering background. Include scientists and engineers engaged in administering research-development, exploration, and all other phases of scientific and engineering work. Exclude all supervisors who spend more time on one of the functions other than management and administration.

EXPLORATION.—Include field and laboratory personnel engaged in exploring and studying areas primarily for the purpose of locating minerals, fuels, and other natural resources. May involve such activities as drilling, examination of fossils, mapping, or specimen collection and analysis. Research on exploration techniques or instruments should be classified in research-development.

PRODUCTION AND OPERATIONS.—Work primarily related to the production processes or operations of a company such as inspection, quality control, etc. Include design, analysis, and testing that are not part of research-development.

ALL OTHER ACTIVITIES.—Include all scientists and engineers engaged in functions not listed separately; for example, technical sales, technical service, technical writing, technical purchasing, and operations research.

BASIC RESEARCH.—Research projects which represent original investigation for the advancement of scientific knowledge and do not have specific commercial objectives, although they may be in fields of present or potential interest to the company.

FULL-TIME EQUIVALENT.—Part-time work in research or development converted into full-time units, each unit equaling the number of hours normally worked per week in reporting company. For example, two employees, each normally working in research-development half the normal workweek, would equal one "full-time equivalent" employee.

FOR ALL COMPANIES SUBMITTING CONSOLIDATED RETURN

PLEASE SUPPLY THE FOLLOWING FOR EACH SEPARATELY INCORPORATED SUBSIDIARY OR AFFILIATE INCLUDED:

Name of Subsidiary or Affiliate	Federal Social Security Employer Identification Number	Total Number of Persons Employed March 1956

Mail completed questionnaire to

COMMISSIONER OF LABOR STATISTICS

U.S. DEPARTMENT OF LABOR

Washington 25, D.C.

U.S. DEPARTMENT OF LABOR
BUREAU OF LABOR STATISTICS
WASHINGTON 25, D.C.

Dear Sir:

A new survey to bring up to date information on the Nation's scientific personnel resources is being conducted by the Bureau of Labor Statistics for the National Science Foundation. Industrial employment of scientists and engineers and related technicians is one of the fast changing factors affecting the Nation's scientific and technical activities. Therefore, annual surveys are considered necessary to keep information as current as possible. These studies provide a basis for evaluating the country's present and future requirements for scientific and technical personnel, and serve as a guide in developing programs to strengthen the Nation's scientific potential. Employers will also find the information useful in assessing their particular scientific manpower situation.

Your company may also receive a questionnaire on research-development expenditures in 1959 (Census Form No. RD-1 or -2). This survey is being conducted for the National Science Foundation by the Bureau of the Census and will yield information on the amount of funds expended for research-development activities in industry. It also contains a question on personnel in research development which may be used to relate the two surveys.

Your cooperation in providing the information requested in the enclosed questionnaire is of great importance to the success of this undertaking. The survey is being conducted on a sampling basis, and a reply is needed from each firm to which a questionnaire is sent, even if the firm does not employ any scientists, engineers, or technicians. The data you supply will be held in strict confidence, and published information will not permit identification of data for individual firms. The second copy of the questionnaire is for your files.

We shall be extremely grateful for a prompt response to the enclosed questionnaire. The success of the previous surveys was due to the generous support of the many organizations which participated in them. Your continuing cooperation will be most helpful.

Very truly yours,

Ewan Clague

Ewan Clague
Commissioner of Labor Statistics

U.S. DEPARTMENT OF LABOR
BUREAU OF LABOR STATISTICS
WASHINGTON 25, D.C.

In reply please
refer to No. 312

Dear Sir:

Several weeks ago we wrote you regarding the 1960 survey of scientific and technical personnel which is being conducted for the National Science Foundation by the Bureau of Labor Statistics. Since we have not heard from you, we are writing to you again to request your cooperation.

The findings of this survey will be used in assessing the country's present and future needs for such personnel and in formulating scientific manpower policies and programs. We hope they will also be useful to employers in evaluating their own scientific personnel needs and policies.

Information for your company is of great importance to the success of this undertaking. Each company receiving a questionnaire is part of a sample which has been carefully selected so that the survey findings will be representative of the Nation as a whole. We need to hear from you even if your company does not employ scientists, engineers, or technicians. Reasonable estimates will be satisfactory. If all data are not available, please supply as much as you can. If the information for your company is being supplied by another organization with which you are affiliated, we should appreciate it greatly if you would notify us.

All information supplied will be kept in strict confidence, and published information will not permit identification of data for individual firms. We are enclosing additional copies of the questionnaire (one for your files), in case the previous ones failed to reach you.

Your cooperation will be greatly appreciated.

Sincerely yours,

Ewan Clague

Ewan Clague
Commissioner of Labor Statistics

Enclosures

U.S. DEPARTMENT OF LABOR
BUREAU OF LABOR STATISTICS
WASHINGTON 25, D.C.

In reply please
refer to No. 312

Dear Sir:

This Bureau is concluding the 1960 survey of scientific and technical personnel conducted for the National Science Foundation. We wrote you about this survey several weeks ago and sent a questionnaire (B.L.S. No. 2674). We are now making a final effort to get certain minimum data from those companies in our sample from which we have not yet heard.

If it is possible for you to reply within two weeks to the questionnaire sent you earlier, it would be most helpful if you would do so. If this is not possible, however, we should appreciate it if you would take a moment of your time now to answer the few items of information requested below, and return this form in the enclosed envelope. A duplicate sheet is provided for your files. All data will be kept confidential, of course. We shall be very grateful for your prompt cooperation.

BEFORE ANSWERING QUESTIONS, PLEASE READ DEFINITIONS ON BACK OF THIS LETTER

1. Please give total number of persons on the payroll of the REPORTING COMPANY in all activities in the United States in January 1960: _____

2. Were any of the persons reported in item 1 working as:

   a. SCIENTISTS or ENGINEERS? Yes ☐ No ☐
   If yes, please give approximate number _____.

   b. TECHNICIANS? Yes ☐ No ☐
   If yes, please give approximate number _____.

Sincerely yours,

Ewan Clague

Ewan Clague
Commissioner of Labor Statistics

Enclosures

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